SOURCES OF WATER:

All the sources of water can be broadly divided into

1. Surfaces sources and

2. Sub surface sources

The surface sources further divided into

i. Streams

ii. Rivers

iii. Ponds

iv. Lakes

v. Impounding reservoirs etc.

NATURAL PONDS AND LAKES

In mountains at some places natural basin's are formed with impervious bed by springs and streams are known as "lakes". The quality of water in the natural ponds and lakes depends upon the basin's capacity, catchment area, annual rainfall, porosity of ground etc. But lakes and ponds situated at higher altitudes contain almost pure water which can be used without any treatment. But ponds formed due to construction of houses, road, railways conatins large amount of impurities and therefore cannot be used for water supply purposes.

STREAMS AND RIVERS

Rivers and streams are the main source of surface source of water. In summer the quality of river water is better than mansoon.because in rainly season the run-off water also carries with clay, sand, silt etc which make the water turbid. So river and stream water require special treatments. Some rivers are snowfed and perennial and have water throughout the year and therefore they donot require any arrangements to hold the water. But some rivers dry up wholly or partially in summer. So they require special arrangements to meet the water demand during hot weather. Mostly all the cities are situated near the rivers discharge their used water of sewege in the rivers, therefore much care should be taken while drawing water from the river.

IMPOUNDING RESERVOIRS

In some rivers the flow becomes very small and cannot meet the requirements of hotweather. In such cases, the water can be stored by constructing a bund, a weir or a dam across the river at such places where minimum area of land is submerged in the water and max. quantity of water to be stored. In lakes and reservoirs, suspended impurities settle down in the bottom, but in their beds algae, weeds, vegetable and organic growth takes place which produce bad smell, taste and colour in water. Therefore this water should be used after purification. When water is stored for long time in reservoirs it should be aerated and chlorinated to kill the microscopic organisms which are born in water.

SUBSURFACE SOURCES

These are further divided into

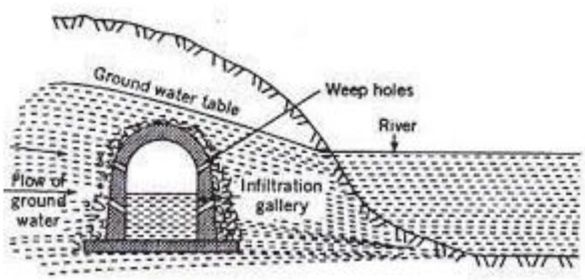
(i) Infiltration galleries

(ii) Infiltration wells

(iii) Springs etc

INFILTRATION GALLERIES

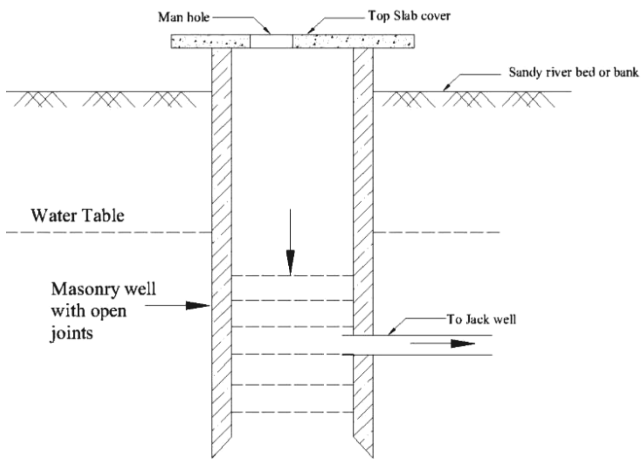
A horizontal nearly horizontal tunnel which is constructed through water bearing strata for tapping underground water near rivers, lakes or streams are called “Infiltration galleries”. The yield from the galleries may be as much as 1.5 x 104 lit/day/metre length of infiltration gallery.



For maximum yield the galleries may be placed at full depth of the acquifer. Infiltration galleries may be constructed with masonary or concrete with weep holes of 5cm x 10cm.

INFILTRATION WELLS

In order to obtain large quantity of water, the infiltration wells are sunk in series in the blanks of river. The wells are closed at top and open at bottom. They are constructed by brick masonary with open joints.



Infiltration Well

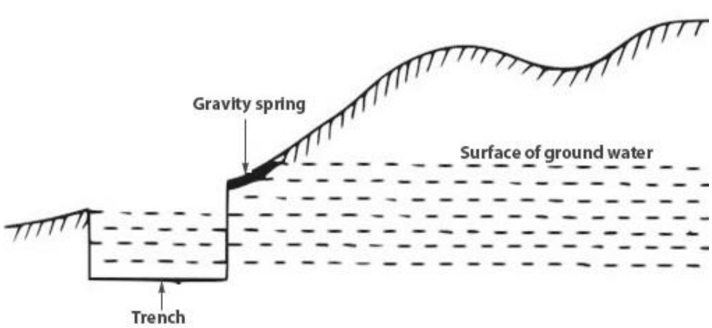
For the purpose of inspection of well, the manholes are provided in the top cover. The water filtrates through the bottom of such wells and as it has to pass through sand bed, it gets purified to some extent. The infiltration well in turn are connected by porous pipes to collecting sump called jackwell and there water is pumped to purification plant for treatment.

SPRINGS:

Sometimes ground water reappears at the ground surface in the form of springs. Springs generally supply small springs. Springs generally supply small quantity of water and hence suitable for the hill towns. Some springs discharge hot water due to presence of sulphur and useful only for the curve of certain skin disease patients.

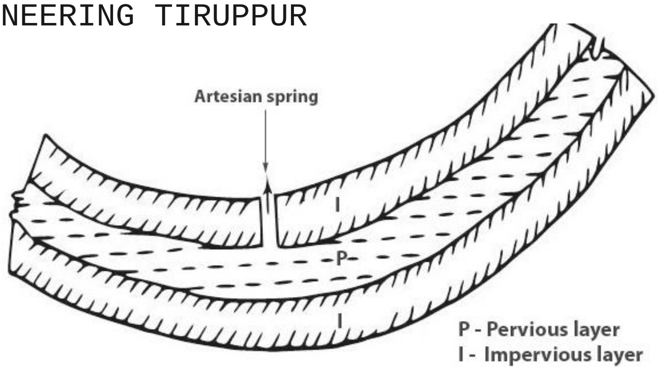
Types of springs:

1.Gravity Springs: When the surface of the earth drops sharply the water bearing stratum is exposed to atmosphere and gravity springs are formed



2. Surface Spring: This is formed when an impervious stratum which is supporting the ground water reservoir becomes out crops

3. Artesian Spring: When the ground water rises through a fissure in the upper impervious stratum when the water-bearing stratum has too much hydraulic gradient and is closed between two imperious stratum, the formation of Artesian spring from deep seated spring



WELLS:

A well is defined as an artificial hole or pit made in the ground for the purpose of tapping water. In India 75 to 85% of Indian population has to depend on wells for its water supply.

The three factors which form the basis of theory of wells are

1. Geological conditions of the earth's surface

2. Porosity of various layers

3. Quantity of water, which is absorbed and stored in different layers.

The following are different types of wells

1. Shallow wells

2. Deep wells

3. Tube wells

4. Artesian wells

Shallow Wells:

Shallow wells are constructed in the uppermost layer of the earth's surface. The diameter of well varies from 2 to 6 m and a maximum depth of 7m. Shallow wells may be lined or unlined from inside. . These wells are also called draw wells or gravity wells or open wells or drag wells or percolation wells. Quantity of water available from shallow wells is limited as their source of supply is uppermost layer of earth only and sometimes may even dry up in summer. Hence they are not suitable for public water supply schemes. The quantity of water obtained from shallow wells is better than the river water but requires purification. The shallow wells should be constructed away from septic tanks, soak pits etc because of the contamination of effluent.The shallow wells are used as the source of water supply for small villages, undeveloped municipal towns, isolated buildings etc because of limited supply and bad quality of water.

Deep Wells:

The Deep wells obtain their quota of water from an aquifer below the impervious layer as shown in fig No. The theory of deep well is based on the travel of water from the outcrop to the site of deep well. The outcrop is the place where aquifer is exposed to the atmosphere. The rain water entered at outcrop and gets thoroughly purified when it reaches to the site of deep well. But it dissolves certain salts and therefore become hard. In such cases, some treatment would be necessary to remove the hardness of water. The depth of deep well should be decided in such a way that the location of out crop is not very near to the site of well. The water available at a pressure greater atmospheric pressure, therefore deep wells are also referred to as a pressure wells.

LABORATORY PROCEDURE TO FIND OUT PHYSICAL, CHEMICAL, BIOLOGICAL:

CHARACTERISTICS OF WATER:

Characteristics of water are physical, chemical and bacteriological which defines water quality.

Physical Characteristics

- Turbidity
- Colour
- Taste and Odour
- Temperature

Turbidity:

If a large amount of suspended solids are present in water, it will appear turbid in appearance. The turbidity depends upon fineness and concentration of particles present in water. Originally turbidity was determined by measuring the depth of column of liquid required to cause the image of a candle flame at the bottom to diffuse into a uniform glow. This was measured by Jackson candle turbidity meter. The calibration was done based on suspensions of silica from Fuller's earth. The depth of sample in the tube was read against the part per million (ppm) silica scales with one ppm of suspended silica called one Jackson Turbidity unit (JTU). Because standards were prepared from materials found in nature such as Fuller's earth, consistency in standard formulation was difficult to achieve. These days turbidity is measured by applying Nephelometry, a technique to measure level of light scattered by the particles at right angles to the incident light beam. The scattered light level is proportional to the particle concentration in the sample. The unit of expression is Nephelometric Turbidity Unit (NTU). The IS values for drinking water is 10 to 25 NTU.

Colour:

Dissolved organic matter from decaying vegetation or some inorganic materials may impart colour to the water. It can be measured by comparing the colour of water sample with other standard glass tubes containing solutions of different standard colour intensities. The standard unit of colour is that which is produced by one milligram of platinum cobalt dissolved in one litre of distilled water. The IS value for treated water is 5 to 25 cobalt units.

Taste and Odour:

Odour depends on the contact of a stimulating substance with the appropriate human receptor cell. Most organic and some inorganic chemicals, originating from municipal or industrial wastes, contribute taste and odour to the water. 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 flavor known as' Flavour Profile Analysis' (FPA). The character and intensity of taste and odour discloses the nature of pollution or the presence of microorganisms.

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 purpose is 5 to 12 °C - above 25 °C, water is not recommended f or drinking.

Chemical Characteristics:

- pH (Power or Percentage of Hydrogen)
- Acidity
- Alkalinity
- Hardness
- Chlorides
- Sulphates
- Iron
- Solids
- Nitrates

pH (Power or Percentage of Hydrogen):

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 water is 6. 5 to 8.5.

Acidity:

The acidity of water is a measure of its capacity to neutralise bases. Acidity of water may be caused by the presence of un-combined carbon dioxide, mineral acids and salts of strong acids and weak bases. It is expressed as mg/ Lit in terms of calcium carbonate. Acidity is nothing but representation of carbon dioxide or carbonic acids. Carbon dioxide causes corrosion in public water supply systems.

Alkalinity:

The alkalinity of water is a measure of its capacity to neutralise acids. It is expressed as mg/Lit in terms of calcium carbonate. The various forms of alkalinity are (a) hydroxide alkalinity (b) carbonate alkalinity (c) hydroxide plus carbonate alkalinity (d) carbonate plus bicarbonate alkalinity, and (e) bicarbonate alkalinity, which is useful mainly in water softening and boiler feed water processes. Alkalinity is an important parameter in evaluating the optimum coagulant dosage.

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 $CaCO_3$.

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. I.S value for drinking water is 250 to 1000 mg/L.

Sulphates:

Sulphates occur in water due to leaching from sulphate mineral and oxidation of sulphides. Sulphates are associated generally with calcium, magnesium and sodium ions. Sulphate in drinking water causes a laxative effect and leads to scale formation in boilers I. t also causes odour and corrosion problems under aerobic conditions. Sulphate should be less than 50 mg/L, for some industries. Desirable limit for drinking water is 150 mg/L. May be extended u pt o 400 mg/L.

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 ions reduced to soluble ferrous ion.Iron can impart bad taste to the water, causes discolouration in clothes and incrustations in water mains. I.S value for drinking water is 0.3 to 1.0 mg/L.

Solids:

The sum of total foreign matter present in water is termed as' total solids'. Totalsolids are the matters that remains as residue after evaporation of the sample and its subsequent drying at a defined temperature (103 to 105 °C). Total solids consist of volatile (organic) and non-volatile(inorganic or fixed) solids. Further, solids are divided into suspended and dissolved solids. Solids that can settle by gravity are settleable solids. The others are non-settleable solids. I.S acceptable limit for total solids is 500 mg/L and tolerable limit is 3000 mg/L of dissolved limits.

Nitrates:

Nitrates in surface waters occur by the leaching of fertilizers from soil during surface run-off and also nitrification of organic matter. Presence of high concentration of nitrates is an indication of pollution. Concentrations of nitrates above 45 mg/L cause a disease methemoglobinemia. I. S value is 45 mg/L.

Bacteriological Characteristics:

Tests to indentify bacteria

- Standard plate count test
- Most probable number
- Membrane filter technique

Standard plate count test:

In this test, the bacteria are made to grow as colonies, by innoculating a known volume of sample into a solidifiable nutrient medium (Nutrient Agar), which is poured in a petridish. After incubating (35°C f) or a specified period (24 hours), the colonies of bacteria (as spots) are counted. The bacterial density is expressed as number of colonies per 100 ml of sample.

Most probable number:

Most probable number is a number which represents the bacterial density which is most likely to be present. E.Coli is used as indicator of pollution. E.Coli ferment lactose with gas formation with 48 hours incubation at 35°C. Based on this E.Coli density in a sample is estimated by multiple tube fermentation procedure, which consists of identification of E.Coli in different dilution combination. MPN value is calculated as follows:

Five 10 ml (five dilution combination) tubes of a sample are tested for E.Co li. If out of five only one gives positive test for E.Coli and all others negative. From the tables, MPN value for one positive and four negative results is read which are 2.2 in present case. The MPN value is expressed as 2.2 per 100 ml. These numbers are given by Maccardy based on the laws of statistics.

Membrane filter technique:

In this test, a known volume of water sample is filtered through a membrane with opening less than 0.5 microns. The bacteria present in the sample will be retained upon the filter paper. The filter paper is put in contact of a suitable nutrient medium and kept in an incubator for 24 hours at 35°C. The bacteria will grow upon the nutrient medium and visible colonies are counted. Each colony represents one bacterium of the original sample. The bacterial count is expressed as number of colonies per 100 ml of sample.

1.2 DESIGN PERIOD

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

It is expressed in years.

- During design period, the structures, equipment and components should be adequate to serve the requirements.
- As per normal procedure water works is designed for a period of 30 years. Influencing factors:
- Useful life of pipes, equipment and structures.
- The anticipated rate of growth. If rate is more, design period will be less.
- The rate of inflation during the period of repayment of loans when inflation rate is high, a longer design period is adopted.
- Efficiency of the component units. The more the efficiency, the longer will be design period.

IMPOUNDING RESERVOIRS:

It is a basin constructed in the valley of a stream or river for the purpose of holding stream flow so that the stored water may be used when supply is insufficient.

They have the following two functions:

(i) To impound water for beneficial use.

(ii) To retard flood.

Two functions may be combined to some extent by careful operations.

An impounding reservoir presents a water surface for evaporation. This loss must be considered. Possibility of large seepage loss must also be considered. If it is economically impossible to prevent them, the project may have to be abandoned or move it to a more favorable site. There will be some loss by seepage through and under the dam itself.

1.2.1 POPULATION FORECASTING METHODS

When the design period is fixed the next step is to determine the population of a town or city population of a town depends upon the factors like births, deaths, migration and annexation. The future development of the town mostly depends upon trade expansion, development industries, and surrounding country, discoveries of mines, construction of railway stations etc may produce sharp rises, slow growth, and stationary conditions or even decrease the population. For the prediction of population, it is better to study the development of other similar towns, which have developed under the same circumstances, because the development of the predicted town will be more or less on the same lines.

Following are the population forecasting methods

- i. Arithmetical increase method
- ii. Geometrical increase method
- iii. Incremental increase method
- iv. Simple graph method
- v. Decrease rate of growth method
- vi. Comparative graph method
- vii. The master plan method

ARITHEMATICAL INCREASE METHOD

This method is based on the assumption that the population is increasing at a constant rate. The rate of change of population with time is constant. The population after 'n' decades can be determined by the formula.

$$P_n = P_0 + n\bar{x}.$$

where

P_0 → population at present

n → No. of decades

$\bar{x}$ → Constant determined by the average of increase of 'n' decadesGEOMETRICAL

INCREASE METHOD

This method is based on the assumption that the percentage increase in population from decade to decade remains constant. In this method the average percentage of growth of last few decades is determined; the population forecasting is done on the basis that percentage increase per decade will be the same.

INCREMENTAL INCREASE METHOD

This method is improvement over the above two methods. The average increase in the population is determined by the arithmetical method and to this is added the average of the net incremental increase once for each future decade.

DECREASING RATE OF GROWTH METHOD

The method is applied to a city that owns a limiting saturation population. In this type, the rate of growth is a function of its population deficit.

COMPARATIVE GRAPH METHOD

In this method, population curve of different cities with similar population growth is studied. The different factors that are taken into consideration are:

The likeness of Economic Base

Proximity of geography

Access to similar transportation systems

MASTER PLAN METHOD

The master plan is prepared for next 25 to 30 years for the city. Master plan the city is divided into various zones such as residence, commerce and industry.

FACTORS INFLUENCING POPULATION GROWTH:

ECONOMIC DEVELOPMENT

Countries that are in the early stages of economic development tend to have higher rates of population growth. In agriculturally based societies, children are seen as potential income earners. From an early age, they can help with household tasks and collecting the harvest. Also, in societies without state pensions, parents often want more children to act as insurance for their old age. It is expected children will look after parents in old age. Because child mortality rates are often higher, therefore there is a need to have more children to ensure the parents have sufficient children to look after them in old age.

SOCIAL AND CULTURAL FACTORS

India and China (before one family policy) had strong social attachments to having large families. In the developed world, smaller families are the norm.

AVAILABILITY OF FAMILY PLANNING

Increased availability of contraception can enable women to limit family size closer to the desired level. In the developing world, the availability of contraception is more limited, and this can lead to unplanned pregnancies and more rapid population growth.

DEATH RATES

Level of medical provision. Often death rates are reduced before a slowdown in birth rates, causing a boom in the population size at a certain point in a country's economic development. In the nineteenth and early twentieth century, there was a rapid improvement in medical treatments which helped to deal with many fatal diseases. Death rates fell and life expectancy increased.

URBANISATION

Rural to urban migration happened in the past centuries in richer nations and is happening today in poorer nations. It has a significant impact upon population growth because it can impact upon the birth and death rates of a country. As a country becomes increasingly urbanized the birth rate tends to rise and death rates tend to fall. The birth rates rise because people have more access to medical care in cities than in rural areas thus infant mortality falls and birth rate rises. This is a short term change, as development occurs over longer periods of time in the urban area birth rates can fall as it is then easier to deliver family planning.

Death rates fall in urban areas because it is cheaper and more economic to provide medical and education services, and to ensure more reliable food supplies. This means that people get more educated, better fed and can be treated when sick. This is often not the case in more remote rural areas so death rates fall in urban areas. The net effect of this is population growth.

INTAKES FOR COLLECTING SURFACE WATER:

The main function of the intakes works is to collect water from the surface source and then discharge water so collected, by means of pumps or directly to the treatment water. Intakes are structures which essentially consist of opening, grating or strainer through which the raw water from river, canal or reservoir enters and carried to the sump well by means of conducts water from the sump well is pumped through the rising mains to the treatment plant.

The following points should be kept in mind while selecting a site for intake works.

1. Where the best quality of water available so that water is purified economically in less time.

2. At site there should not be heavy current of water, which may damage the intake structure.

3. The intake can draw sufficient quantity of water even in the worst condition, when the discharge of the source is minimum.

4. The site of the work should be easily approachable without any obstruction

5. The site should not be located in navigation channels

6. As per as possible the intake should be near the treatment plant so that conveyance cost is reduced from source to the water works

7. As per as possible the intake should not be located in the vicinity of the point of sewage disposal for avoiding the pollution of water.

8. At the site sufficient quantity should be available for the future expansion of the water-works.

Types of Intake structures:

Depending upon the source of water the intake works are classified as following

1. Lake Intake

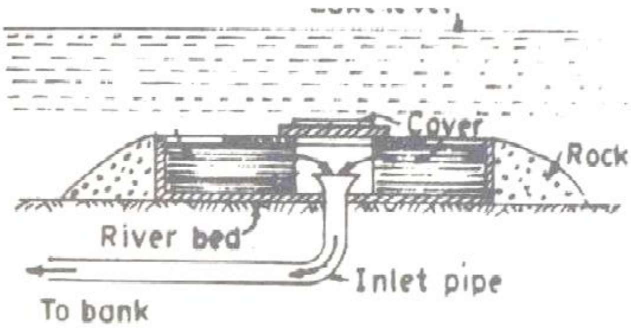
2. Reservoir Intake

3. River Intake

4. Canal Intake

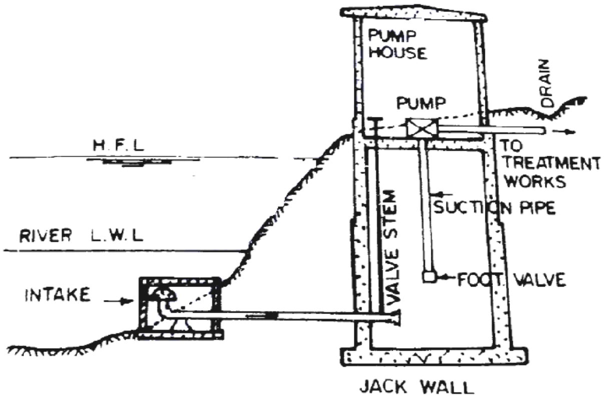
1. LAKE INTAKE:

For obtaining water from lakes mostly submersible intakes are used. These intakes are constructed in the bed of the lake below the water level; so as to draw water in dry season also. These intakes have so many advantages such as no obstruction to the navigation, no danger from the floating bodies and no trouble due to ice. As these intakes draw small quantity of water, these are not used in big water supply schemes or on rivers or reservoirs. The main reason being that they are not easily approachable for maintenance.



2. RIVER INTAKE:

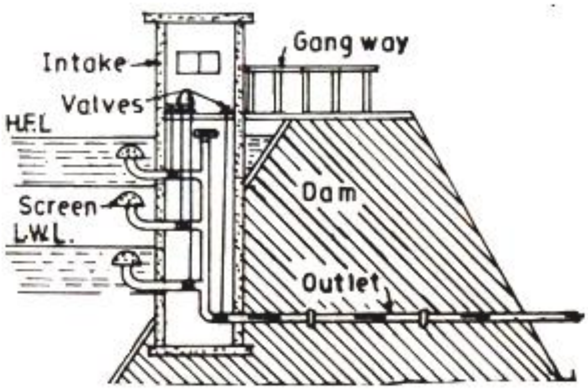
Water from the rivers is always drawn from the upstream side, because it is free from the contamination caused by the disposal of sewage in it. It is circular masonary tower of 4 to 7 m in diameter constructed along the bank of the river at such place from where required quantity of water can be obtained even in the dry period. The water enters in the lower portion of the intake known as sump well from penstocks.



River Intake

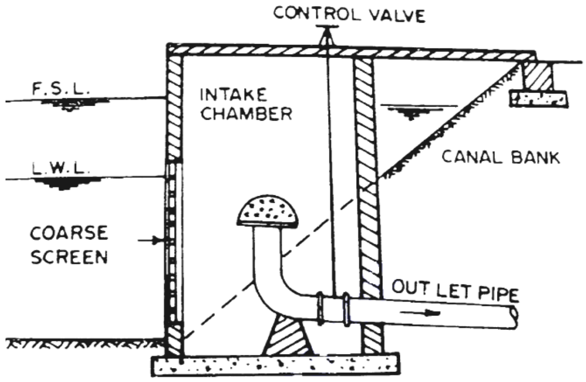
3. RESERVOIR INTAKE:

It consists of an intake well, which is placed near the dam and connected to the top of dam by foot bridge. The intake pipes are located at different levels with common vertical pipe. The valves of intake pipes are operated from the top and they are installed in a valve room. Each intake pipe is provided with bell mouth entry with perforations of fine screen on its surface. The outlet pipe is taken out through the body of dam. The outlet pipe should be suitably supported. The location of intake pipes at different levels ensures supply of water from a level lower than the surface level of water. When the valve of an intake pipe is opened the water is drawn off from the reservoir to the outlet pipe through the common vertical pipe. To reach upto the bottom of intake from the floor of valve room, the steps should be provided in Zigzag manner.



4. CANAL INTAKE:

An intake chamber is constructed in the canal section. This results in the reduction of water way which increases the velocity of flow. It therefore becomes necessary to provide pitching on the downstream and upstream portion of canal intake. The entry of water in the intake chamber takes through coarse screen and the top of outlet pipe is provided with fine screen. The inlet to outlet pipe is of bell-mouth shape with perforations of the fine screen on its surface. The outlet valve is operated from the top and it controls the entry of water into the outlet pipe from where it is taken to the treatment plant.



Canal Intake

2.1 SEDIMENTATION PROCESS

2.1.1 UNIT OPERATIONS AND PROCESSES

Unit operations are the physical operations to remove the impurities present in the water and waste water where as the unit processes are the chemical and biological conversion on the status of the impurities that they will be converted to a form that can be easily separated. Both are applied especially to make the fine colloidal particles to coalesce and grow in size to be removed from the water or waste water. There is no impurity that can be categorized as inorganic, it is named so for it takes time to disintegrate and had been to this hard form, free from decomposable matter with the ecological factors. We can find metal eating bacteria these days that makes the accelerated form to human use get decelerated to favor nature accommodate effectively as indigenous.

Screens are in use from the intake structure where they prevent the floating matter to enter into the pumping units, and fine and coarse screens are in use to treat waste water to prevent the entry of floating wastes and coarse solids into the treatment.

Sedimentation is simply detaining water for a sufficient time mostly in stagnant or relatively stagnant position to make the flow velocity of water less than the settling velocity of the solid particles that they without being driven by horizontal force settles down by gravity. The efficiency of the process depends on the detention time, how long the waste water remains within the sedimentation tank. When applied to individual units we need not reduce the flow velocity but make it stagnant as fill and draw type that the efficiency will be more. In the continuous flow type the flow velocity is reduced to the level of the minimum velocity which will not carry the particles with it according to stokes law that the vertical velocity, which is the settling velocity of the particle will be more than the horizontal drag velocity and the particle settles down. Mostly the tanks will be rectangular and we also have circular tanks where the flow will be from centre to periphery. Whatever may be the shape of the tank, it is the surface area which makes the travel of particles independent of others which makes the settling efficient that the depth has to be considered taking into effect the sludge accumulation and to prevent the reentry of particles back to flow.

Filtration is to the removal of fine particle sand dissolved solids where the fine sand layer and coarse sand layer below serves as the media to remove colloidal solids and the water remains completely free of solids. In trickling filters the waste water that trickles down gets oxidized that the organic matter grows in size and retained over the sand medium and bacteria assimilate on the organic matter to form layer on the surface which grows thicker and thicker to give more bacterial mass to act upon the organic solids. The bottom most layer becomes deprived of oxygen in due course of time that it sloughs and the same reaches the secondary settling tank where the same gets settled for its increased density.

Odour and colour present in water and waste water are removed by aeration and adsorption process. The odour and colour causing elements are adsorbed and aerated that the water is free from impurities for use and waste water for reuse and recycling. Toxic chemicals and metals too get adsorbed with suitable media for adsorption.

Unit processes:

Flocculation is a water treatment process where solids form larger clusters, or flocs, to be removed from water. This process can happen spontaneously, or with the help of chemical agents.

Coagulation is the chemical water treatment process used to remove solids from water, by manipulating electrostatic charges of particles suspended in water. This process introduces small, highly charged molecules into water to destabilize the charges on particles, colloids, or oily materials in suspension.

Coagulants are added to the water that the flocculent particles grow bigger in size which is by chemical reaction by rapid mixing and slow mixing and the coalescent particles which grew in size gets removed by settling. The coagulant we add changes the quality of water and the sludge volume too, and some of the coagulants add to bulking of sludge where the removal of moisture is difficult. Lime water instead of lime reduces the volume of sludge which is to all the solid coagulants. Liquid coagulants have more influence readily on coagulant particles than the solid coagulants which itself will take time to dissolve and react with the particles.

Chlorination is the process of adding chlorine or chlorine compounds such as sodium hypochlorite to water. This method is used to kill bacteria, viruses and other microbes in water. In particular, chlorination is used to prevent the spread of waterborne diseases such as cholera, dysentery, and typhoid.

The unit operations and processes can be applied in individual units of houses, colonies and industries that it gives fewer problems to the environment and handled with more efficiency. The entire process of sedimentation, filtration and hardness removal can be done at home, for removal of hardness we need not go for reverse osmosis which is much expensive on installation and maintenance but the simple lime soda process or boiling serve the purpose of both disinfection and hardness removal as the water from the top stratum of aquifer will not be saline in nature with chlorides and sulphates of calcium and magnesium as is seen common with river water discharged with domestic and industrial wastes. The lime soda solution can be sold commercially to separate salts in the tank and that can be removed very frequently. There are plant extracts that helps removing salinity too.

Construction, Operation and Maintenance Aspects of water treatmentplant:

Construction aspect:

- Must follow building code of practice when installing
- Use of materials is also need to followed as per standards
- Proper material and workmanship
- Pipe diameter, threads, wall thickness, pressure class, corrosion protection, hoop stress, buried depth, surge protection, thrust restraint, pipe bedding, and jointing should all be considered.

O & M aspect:

Tasks can be broken down into daily, weekly, monthly, and seasonal repeats.

Daily Tasks:

- Check water meter readings and record water use.
- Check and record water level indicators in reservoir/storage tanks.
- Check and record chlorine level in the distribution system.
- Inspect chemical feed pumps for proper operation.
- Inspect well pumps, motors, pressure gauges, and controls. Record well pump running times and pump cycle starts.
- Record and investigate customer complaints.
- Inspect heater operation during winter months.

Weekly Tasks

- Inspect chlorine testing equipment.
- Check chemical solution tanks and record use.
- Clean pump house and grounds.
- Make sure fire hydrants are accessible.
- Record pumping rate for each well or source water pump.
- Inspect pump house plumbing for leaks.
- Take bacteriological sample in for testing

  (Required testing frequency may vary -- check with your local health authority).

Monthly, Seasonal, or Annual Tasks

- Take and record electrical meter readings at pump house.
- Inspect well head or intake structure.
- Inspect reservoir.

2.1.2 SEDIMENTATION TANK

It is the process in which the suspended solids are made to settle by gravity under still water conditions is called plain sedimentation.

PLAIN SEDIMENTATION

By plain sedimentation the following are the advantages.

- Plain sedimentation lightens the load on the subsequent process.
- The operation of subsequent purification process can be controlled in better way.
- The cost of cleaning the chemical coagulation basins is reduced.
- No chemical is lost with sludge discharged from the plain settling basin.
- Less quantity of chemicals is required in the subsequent treatment processes.

The amount of matter removed by sedimentation tank depends upon the factors.

- Velocity of flow
- size and shape of particles
- Viscosity of water

The particles which do not change in size, shape or mass during settling are known as the discrete particles. The velocity of discrete particles with dia less than 0.1 mm is given by

V = 418 (S - S1) d2 (3T + 70) -------------------------- (1)

Where V → Velocity of settlement in mm/sec

S → Specific gravity of the particle

S1 → Specific gravity of water

D → dia of the particle in mm

T → Temperature in °C

If the dia of the particle is greater than 0.1mm then the velocity is measured by

V = 418 (S - S1) d (3T + 70) ---------------------------(2)

In practice settling of the particles governed by the resultant of horizontal velocity of water and the vertical downward velocity of the particle.

DESIGN ASPECTS OF SEDIMENTATION TANKS

The design aspects of sedimentary tanks are

- Velocity of flow
- Capacity of tank
- Inlet and outlet arrangements
- Shapes of tanks
- Miscellaneous considerations.

(1) Velocity of flow: The velocity of flow of water in sedimentation tanks should be sufficient enough to cause the hydraulic subsidence of suspended impurities. It should remain uniform throughout the tank and it is generally not allowed to exceed 150mm to 300mm per minute.

(2) Capacity of tank: capacity of tank is calculated by

i) Detention period

ii) Overflow rate

(i) Detention period: The theoretical time taken by a particle of water to pass between entry and exit of a settling tank is known as the known as the detention period. The capacity of tank is calculated by

C = Q x T where C → Capacity of tank

Q → Discharge or rate of flow

T → Detention period in hours

The detention period depends on the quality of suspended impurities present in water. For plain sedimentation tanks, the detention period is found to vary from 4 to 8 hours.

(ii) Overflow Rate: in this method it is assumed that the settlement of a particle at the bottom of the settlement of a particle at the bottom of the tank does not depend on the depth of tank and depends upon the surface area of the tank.

Distance of descend D

Surface overflow rate, V

C L x B x D L x B

Where L → Length of tank

B → Breadth of tank

D → Depth of tank = Side water depth = S.W.D

C → Capacity of tank

T → Detention period

U → Discharge or rate of flow

V → Velocity of descend of a particle to the bottom of tank

Surface overflow rate = S.O.R

(3) INLET AND OUTLET ARRANGEMENTS

The inlet is a device, which is provided to distribute the water inside a tank, and the outlet is a device, which is meant to collect outgoing water. These arrangements should be properly designed and located in such a way that they do not form any obstruction or cause any disturbance to the flowing water.

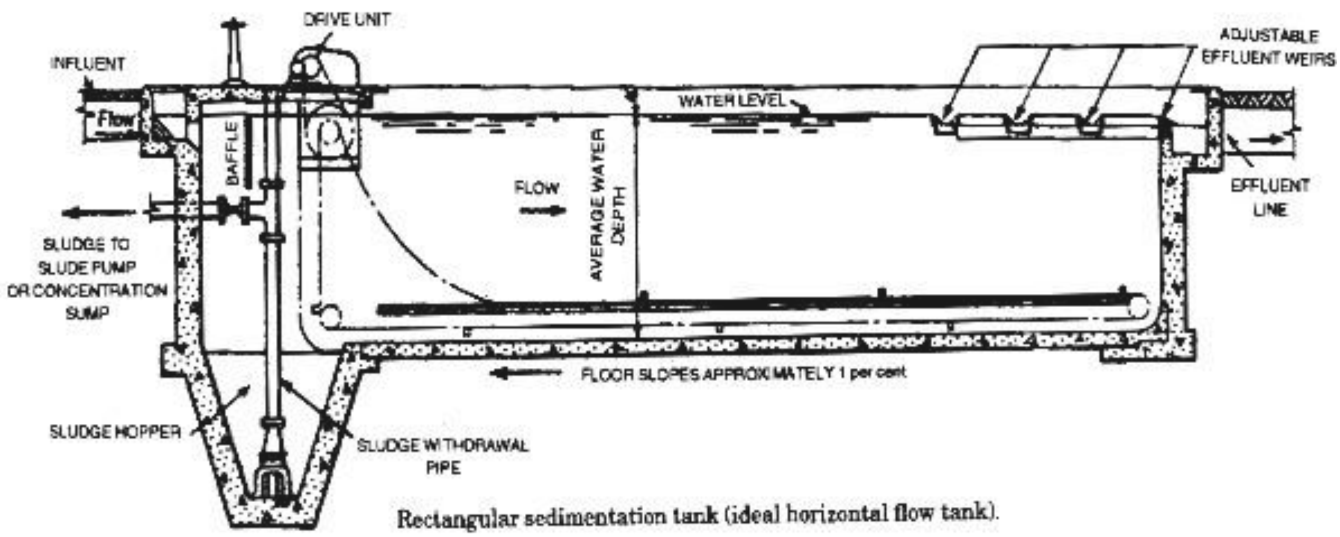
(4) SHAPES OF TANKS

Following are the three shapes of settling tank.

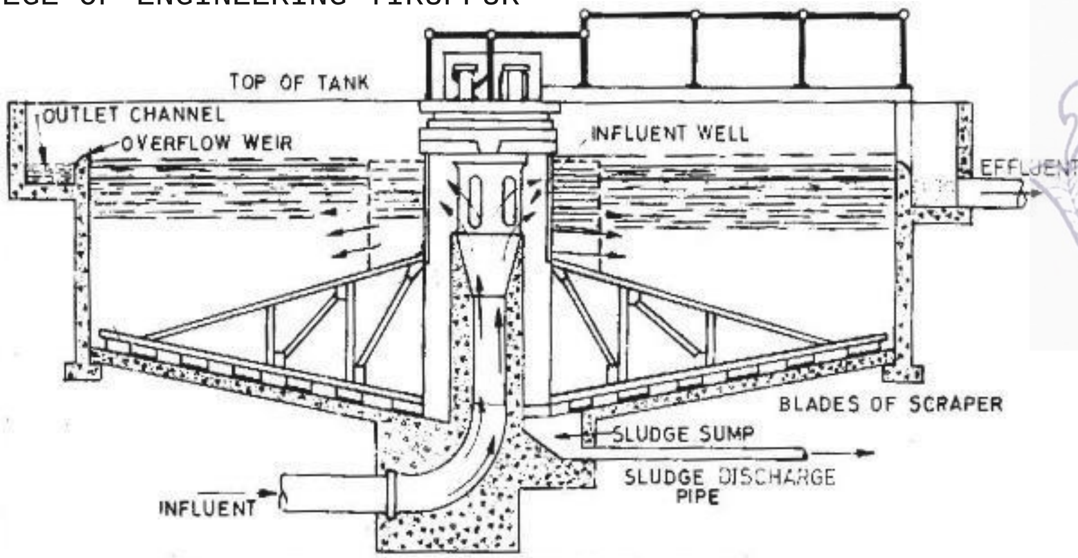
(i) Rectangular tanks with horizontal flow

(ii) Circular tanks with radial or spiral flow

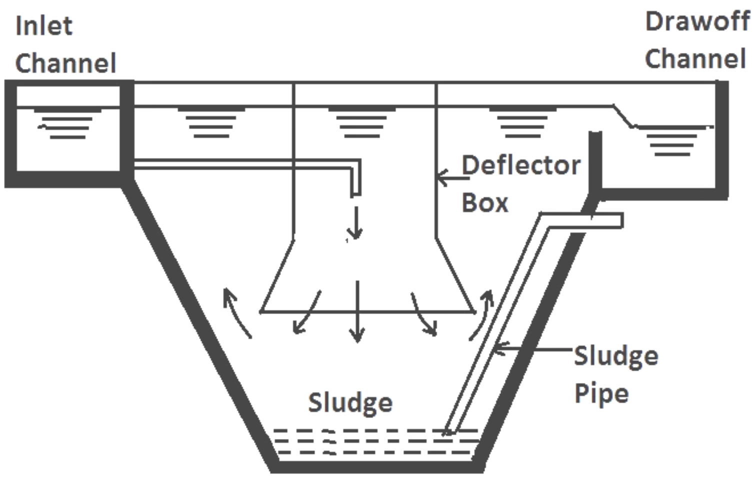
(iii) Hopper bottom tanks with vertical flow



Rectangular sedimentation tank (ideal horizontal flow tank).



Circular sedimentation tank (central feed) with radial flow.



Hopper Bottom Tank

The following are the parameters for satisfactory performance.

- Detention period ….. 3 to 4 hours for plain settling.
  2 to 21/2 hours for coagulant settling
  1 to 11/2 hours for up flow type
- Overflow rate ……… 30 – 40 m3/m2/day for horizontal flow
  40-50m3/m2/day for up flow
- Velocity of flow ....0.5 to 1.0 cm/sec
- Weir loading................300m3/m/day
- L:B ....1:3 to 1:4
- Breadth of tank…...... (10 to 12m) to 30 to 50m
- Depth of tank…..........21/2 – 4m
- Diameter of circular tank…. upto 60m
- Solids removal efficiency… ..50%
- Turbidity of water after sedimentation – 15 to 20 N.T.U.
- Inlet and Outlet zones ....0.75 to 1.0m

- Free board… 0.5m
- Sludge Zone 0.5m

Settling Solid liquid separation process in which a suspension is separated into two phases:

- Clarified supernatant leaving the top of the sedimentation tank (overflow).
- Concentrated sludge leaving the bottom of the sedimentation tank

(underflow).Purpose of Settling:

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

filters.Principle of Settling:

- Suspended solids present in water having specific gravity greater than that of water tend to settle down by gravity as soon as the turbulence is retarded by offering storage.
- Basin in which the flow is retarded is called settling tank.
- Theoretical average time for which the water is detained in the settling tank is called the detention period.

Types of Settling:

Type I: Discrete particle settling - Particles settle individually without interaction with neighboring particles.

Type II: Flocculent Particles – Flocculation causes the particles to increase in mass and settle at a faster rate.

Type III: Hindered or Zone settling –The mass of particles tends to settle as a unit with individual particles remaining in fixed positions with respect to each other.

Type IV: Compression – The concentration of particles is so high that sedimentation can only occur through compaction of the structure.

2.2 AERATORS AND FLASH MIXERS

Aeration:

Aeration is a process in which water is brought in intimate contact with atmospheric airto promote exchange of gases between water and atmospheric air.

(i) Oxygen from atmospheric air is absorbed by water thereby oxygen deficiency of water is eliminated and also freshness is imparted to water.

(ii) Carbon dioxide, hydrogen sulphide and other volatile substances imparting taste and odour to water are easily expelled by aeration.

(iii) Iron and manganese present in water are oxidized to certain extent by aeration.

The following four types of aerators are generally adopted for aeration in the treatment of water:

Diffused Air Aerators:

A diffused air aerator consists of a tank or basin in which at the bottom perforated pipes are provided. The water to be aerated is filled in the tank and compressed air is blown through the perforated pipes. The air bubbles emerging from the perforations rise up from the bottom of the tank. While rising up the air bubbles come in close contact with water contained in the tank, and aeration of water is thus achieved. The tanks are generally 3 to 4.5 m deep and 3 to 9 m wide.

Cascade Aerators:

In cascade aerators water is allowed to flow downwards after spreading over inclined thin sheets and the turbulence is created by allowing water to pass through a series of steps or baffles. The number of steps is usually 4 to 6. Water is allowed to fall through a height of about 1 to 3 m. In this case removal of gas varies from 20 to 45 percent of carbon dioxide and about 35 percent of hydrogen sulphide.

Spray Aerators:

In spray aerators water is sprayed through nozzles upwards into atmosphere and broken up into either a mist of droplets. The installation consists of fixed nozzles on a pipe grid and trays for collecting the sprayed water. Nozzles usually have diameters varying from 10 to 40 mm spaced at intervals of 0.5 to 1 m or more. The pressure required at the nozzle head is usually 7m of water but it may vary from 2 to 9 m of water. The discharge rating per nozzle varies from 18to36 m^3/hour.

Multiple Tray Aerators:

A water-fall or multiple tray aerators consists of a number of trays with perforated bottoms, arranged vertically in series. Water flowing through a riser pipe is discharged through perforated pipes into the top most trays and after flowing down through each of the lower trays, it is collected in a basin provided at the base. During the downward flow through trays water comes in contact with atmospheric air and thus aeration takes place. Usually trays about 4 to 9 in number with spacing of 300 to 750 mm are provided. In most aerators coarse media such as coke, stone or ceramic balls ranging from 50 to 150 mm in diameter are placed in the trays to increase the efficiency of aeration.

Treatment by Activated Carbon:

Activated carbon is used to remove colour, taste and odour from water. Activated carbon is produced by heating a carbonaceous material such as coke, charcoal, paper mill waste, saw dust, lignite, etc., in a closed vessel at a high temperature. It is then activated or oxidised by passing air, steam, carbon dioxide, chlorine or flue gases. The activation of the carbonaceous materials removes the hydrocarbons which might interfere with the adsorption of organic matter.

The activated carbon is available in various trade names such as Darco, Nuchar and Minchar. It is available in granular as well as powder form. The grains are of 6 mm size and below. Its weight is 4 kN per m and it is highly porous in structure. Activated carbon removes organic contaminants from water by the process of adsorption. In adsorption high surface area is the prime consideration. Granular activated carbons typically have surface areas of 500- 1400m /gm.

Activated carbon treatment has the following advantages:

(i) It helps the process of coagulation, if adopted before filtration of water.

(ii) It reduces the chlorine demand of treated water.

(iii) It removes tastes, odours and colours caused by the presence of excess chlorine, hydrogen sulphide, phenol, iron, manganese, etc.

(iv) It removes organic matter present in water.

(v) It is effective in preventing or retarding the decomposition of sludge in settling basins.

(vi) Its overdose is harmless.

Use of Copper Sulphate:

Copper sulphate $CuSO_4$ is used to serve the following two purposes:

(i) Removal of colour, odour and taste from water.

(ii) Control the growth of algae, bacteria and some types of aquatic weeds.

2.2.1 AERATION

Aeration removes odour and tastes due to volatile gases like hydrogen sulphide and due to algae and related organisms. Aeration also oxidise iron and manganese, increases dissolved oxygen content in water, removes CO2 and reduces corrosion and removes methane and other flammable gases.

Principle of treatment underlines on the fact that volatile gases in water escape into atmosphere from the air-water interface and atmospheric oxygen takes their place in water, provided the water body can expose itself over a vast surface to the atmosphere. This process continues until an equilibrium is reached depending on the partial pressure of each specific gas in the atmosphere.

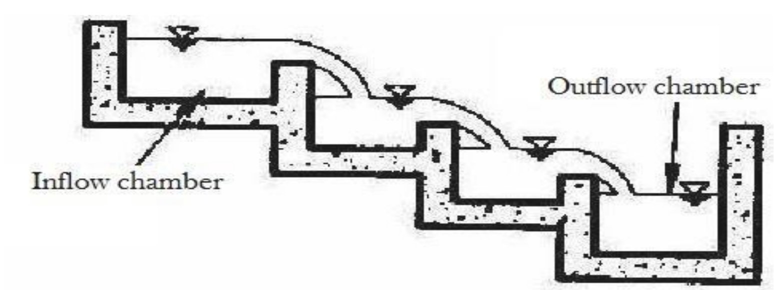
Principle of Aeration

Oxygen uptake depends on the area and duration of contact between water and air. For porous air diffusers this means that the size of the bubbles should be relatively small, since surface area is bigger in proportion to their volume and they rise slower, which gives a longer contact duration.

Types of Aerators

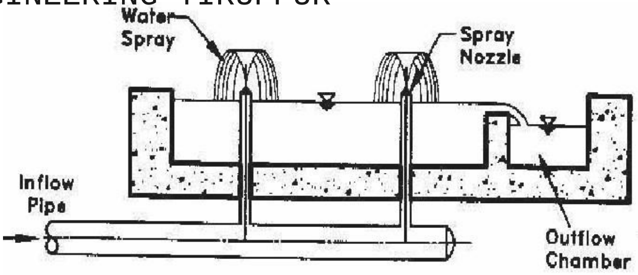
1. Gravity aerators
2. Fountain aerators
3. Diffused aerators
4. Mechanical aerators.

Gravity Aerators (Cascades): In gravity aerators, water is allowed to fall by gravity such that a large area of water is exposed to atmosphere, sometimes aided by turbulence.



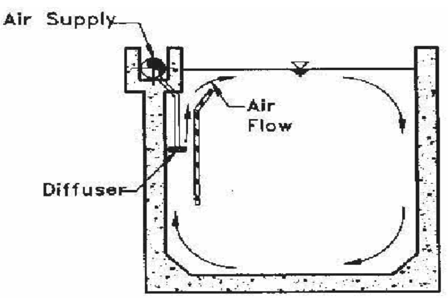
Cascade type Gravity Aerator

Fountain Aerators: These are also known as spray aerators with special nozzles to produce a fine spray. Each nozzle is 2.5 to 4 cm diameter discharging about 18 to 36 l/h. Nozzle spacing should be such that each m3 of water has aerator area of 0.03 to 0.09 m2 for one hour.



Injection or Diffused Aerators :

It consists of a tank with perforated pipes, tubes or diffuser plates, fixed at the bottom to release fine air bubbles from compressor unit. The tank depth is kept as 3 to 4 m and tank width is within 1.5 times its depth. If depth is more, the diffusers must be placed at 3 to 4 m depth below water surface. Time of aeration is 10 to 30 min and 0.2 to 0.4 litres of air is required for 1 litre of water.



Mechanical Aerators:

Mixing paddles as in flocculation are used.

Paddles may be either submerged or at the surface.

FUNCTIONS OF AERATORS

1. Aeration brings water and air in close contact in order to remove dissolved gases (such as carbon dioxide) and oxidizes dissolved metals such as iron, hydrogen sulfide, and volatile organic chemicals (VOCs). Aeration is often the first major process at the treatment plant. During aeration, constituents are removed or modified before they can interfere with the treatment processes.

2. Aeration brings water and air in close contact by exposing drops or thin sheets of water to the air or by introducing small bubbles of air (the smaller the bubble, the better) and letting them rise through the water. The scrubbing process caused by the turbulence of aeration physically removes dissolved gases from solution and allows them to escape into the surrounding air.

3. Aeration also helps remove dissolved metals through oxidation, the chemical combination of oxygen from the air with certain undesirable metals in the water. Once oxidized, these chemicals fall out of solution and become particles in the water and can be removed by filtration or flotation.

4. Oxygen is added to water through aeration and can increase the palpability of water by removing the flat taste. The amount of oxygen the water can hold depends primarily on the temperature of the water. (The colder the water, the more oxygen the water can hold).

5. Water that contains excessive amounts of oxygen can become very corrosive. Excessive oxygen can also cause problems in the treatment plant i.e. air binding of filters.

2.5 COAGULATION AND DISINFECTION

When water contains fine clay and colloidal impurities which are electrically charged are continually in motion and never settle down due to gravitational force. Certain chemicals are added to the water so as to remove such impurities which are not removed by plain sedimentation. The chemical form insoluble, gelatinous, flocculent precipitates absorb and entangle very fine suspended matter and colloidal impurities during its formation and descent through water. These coagulants further have an advantage of removing colour, odour and taste from the water. Turbidity of water reduced upto 5-10 ppm and bacteria removes up to 65%. The following are the mostly used Coagulants with normal dose and PH values required for best floc formation. Coagulant PH Range Dosage mg/l

1. Aluminium sulphate $Al2(SO4)3$, 18 $H2O$ 5.5 – 8.0 5 – 85

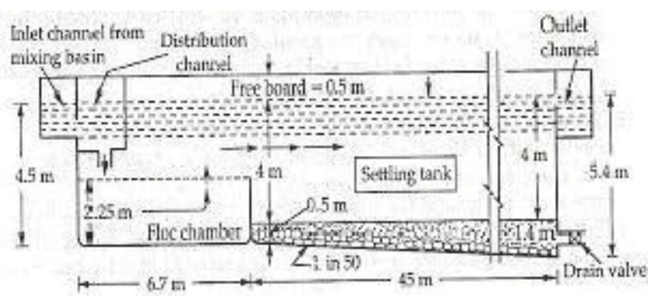
2. Sodium Aluminate, $Na2Al2O4$ 5.5 – 8.0 3.4 – 34

3. Ferric Chloride ($Fecl3$) 5.5 – 11.0 8.5 – 51

4. Ferric Sulphate $Fe2 (SO4)3$ 5.5 – 11.0 8.5 – 51

5. Ferric Sulphate $FeSO47H2O$ 5.5 – 11.0 8.5 - 51

Coagulants are chosen depending upon the PH of water. Alum or Aluminium sulphate is normally used in all treatment plants because of the low cost and ease of storage as solid crystals over long periods. The dosage of coagulants, which should be added to the water, depends upon kind of coagulant, turbidity of water, colour of water, PH of water, temperature of water and temperature of water and mixing & flocculation time. The optimum dose of coagulant required for a water treatment plant is determined by a Jar test. For starting the experiment first of all the sample of water is taken in every jar and added the coagulant in a jar in varying amounts. The quantity of coagulant added in each jar is noted. Then with the help of electric motor all the paddles are rotated at a speed of 30-40 R.P.M. for about 10 minutes. After this the speed is reduced and paddles are rotated for about 20-30 minutes. The rotation of paddles is stopped and the floc formed in each Jar is noted and is allowed to settle. The dose of coagulant which gives the best floc is the optimum dose of coagulants.



Dimensions of the Coagulation-cum-Sedimentation tank

The coagulants may be fed or allowed to enter either in powder form called dry feeding or in solution form called wet feeding. The mixing of coagulant with the water to form the floc by the following method:

1. Centrifugal pump
2. Compressed air
3. Hydraulic jump
4. Mixing channel
5. Mixing basins with buffle walls
6. Mixing basins with mechanical means

Now a day's some firms manufacture combined unit comprising of feeding, mixing, flocculator and clarifier device.

Sedimention with Coagulation:

Water enters in this tank through central inlet pipe placed inside the deflector box. The deflector box deflects the water downwards and then it goes out through the holes provided sides of the deflector box. The water flows radially from the deflector box towards the circumference of the tank, where outlet is provided on the full periphery. All the suspended particles along with floc settle down on the sloppy floor and clear water goes through outlet. The sludge is removed by scrapper who continuously moves around the floor with very small velocity. Disinfection and repainting is to be carried out once in a year before monsoon. Sludge pipes are to be flushed and kept clean. Bleaching powder may be used to control the growth of algae on the weirs. Scraper mechanism should be oiled and greased periodically.

2.3.1 CHLORINATION

Chlorination is the addition of chlorine to kill the bacteria Chlorination is very widely adopted in all developing countries for treatment of water for public supply. Chlorine is available in gas, liquid or solid form (bleaching powder)

ADVANTAGES OF CHLORINE

1. Chlorine is manufactured easily by electrolytes of common salts (NaCl).
2. It is powerful oxidant and can penetrate the cell wall of organism and its contents.
3. Dosage can be controlled precisely.
4. Can be easily detected by simple orthotolidine test.
5. Does not form harmful constituents on reaction with organics of inorganic in water.

RESIDUAL CHLORINE AND CHLORINE DEMAND

When chlorine is applied in water some of it is consumed in killing the pathogens, some react organs & inorganic substances and the balance is detected as "Residual Chlorine". The difference between the quantity applied per liter and the residual is called "Chlorine Demand". Polluted waters exert more chlorine demand. If water is pre-treated by sedimentation and aeration, chlorine demand may be reduced. Normally residual chlorine of 0.2 mg/liter is required.

DOSAGE OF CHLORINE

(A) PLAIN CHLORINATION

Plain chlorination is the process of addition of chlorine only when the surface water with no other treatment is required. The water of lakes and springs is pure and can be used after plain chlorination. A rate of 0.8 mg / lit / hour at 15N / cm^2 pressure is the normal dosage so as to maintain in resided chlorine of 0.2 mg/lit.

(B) SUPER CHLORINATION

Super chlorination is defined as administration of a dose considerably in excess of that necessary for the adequate bacterial purification of water. About 10 to 15 mg/lit is applied with a contact time of 10 to 30 minutes under the circumstances such as during epidemic breakout water is to be dechlorinated before supply to the distribution system.

(C) BRAKE POINT CHLORINATION

When chlorine is applied to water containing organics, micro organisms and ammonia the residual chlorine levels fluctuate with increase in dosage Upto the point B it is absorbed by reducing agents in water (like nitrates, Iron etc) further increases forms chloramines with ammonia in water. Chloramines are effective as CL and OCL formed. When the free chlorine content increases it reacts with the chloramines and reducing the available chlorine. At the point „D" all the chloramines are converted to effective N2, N2O and NCl3. Beyond point „D" free residual chlorine appear again. This point „D" is called break point chlorination. Dosage beyond this point is the same as super chlorination. In super chlorination no such rational measurement is made and the dosage is taken at random.

(D) DECHLORINATION

Removal of excess chlorine resulting from super chlorination in part or completely is called „Dechlorination". Excess chlorine in water gives pungent smell and corrodes the pipe lines. Hence excess chlorine is to be removed before supply. Physical methods like aeration, heating and absorption on charcoal may be adopted. Chemical methods like sulphur dioxide (SO2), Sodium Bi-sulphate (NaHSO3),Sodium Thiosulphate(Na2S2O8) are used.

POINTS OF CHLORINATION

Chlorine applied at various stages of treatment and distribution accordingly they are known as pre, post and Re-chlorination.

a) PRE-CHLORINATION

Chlorine applied prior to the sedimentation and filtration process is known as Prechlorination. This is practiced when the water is heavily polluted and to remove taste, odour, color and growth of algae on treatment units. Pre-chlorination improves coagulation and post chlorination dosage may be reduced.

b) POST CHLORINATION

When the chlorine is added in the water after all the treatment is known as Post chlorination.

c) RE-CHLORINATION

In long distribution systems, chlorine residual may fall tendering the water unsafe. Application of excess chlorine to compensate for this may lead to unpleasant smell to consumers at the points nearer to treatment point in such cases chlorine is applied again that is rechlorinated at intermediate points generally at service reservoirs and booster pumping stations.

2.3.2 DISINFECTION OF WATER

The process of killing the infective bacteria from the water and making it safe to the user is called disinfection. The water which comes out from the filter may contain some disease – causing bacteria in addition to the useful bacteria. Before the water is supplied to the public it is utmost necessary to kill all the disease causing bacteria. The chemicals or substances which are used for killing the bacteria are known as disinfectants.

REQUIREMENTS OF GOOD DISINFECTANTS

1. They should destroy all the harmful pathogens and make it safe for use.
2. They should not take more time in killing bacteria.
3. They should be economical and easily available.
4. They should not require high skill for their application.
5. After treatment the water should not become toxic and objectionable to the user.
6. The concentration should be determined by simply and quickly.

METHODS OF DISINFECTION

Disinfection of water by different physical and chemical methods

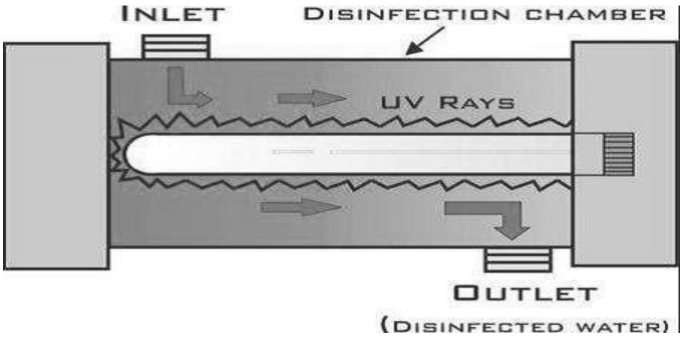
I. PHYSICAL METHODS

1. Boiling:

Boil the water for 15 to 20 minutes and kills the disease causing bacteria. This process is applicable for individual homes.

2. Ultra-violet rays:

Water is allowed to pass about 10cm thickness by ultraviolet rays. This process is very costly and not used at water works. Suitable for institutions.



II. CHEMICAL METHODS

1. 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 of 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 recarbonation for lime removal should be used after disinfection.

2. Chlorination:

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.

3. Bromine and Iodine:

Use of iodine or bromine is limited to small water supplies such as swimming pools, troops of army, private plants, etc.

- Dosage of iodine or bromine is about 8 p.p.m.
- Contact period with water is 5 minutes.
- Available in the form of pellets or small pills.

4. POTASSIUM PERMANGANATE TREATMENT ($KMnO_4$)

- It is a powerful oxidising agent, effective in killing cholera bacteria
- Restricted to disinfection of water of village wells and ponds
- Dosage is about 2.1 ppm
- Contact period of 3 to 4 hours
- The treated water produces a dark brown coating on porcelain vessels and this is difficult to remove except with scratching or rubbing

5. SILVER TREATMENT

- Colloidal silver is used to preserve the quality of water stored in jars.
- Metallic silver is placed as filter media. Water get purified while passing through these filters.
- Dosage of silver varies from 0.05 to 1 p.p.m.
- Contact period is about 15 minutes to 3 hours.
- It is costly and limited to private individual houses only.

2.4 FILTRATION OF WATER

The process of passing the water through beds of sand or other granular materials are known as filtration. For removing bacteria, colour, taste, odours and producing clear and sparkling water, filters are used by sand filtration 95 to 98% suspended impurities are removed.

THEORY OF FILTRATION:

The following are the mechanisms of filtration

1. Mechanical straining – Mechanical straining of suspended particles in the sand pores.
2. Sedimentation – Absorption of colloidal and dissolved inorganic matter in the surface of sand grains in a thin film.
3. Electrolytic action – The electrolytic charges on the surface of the sand particles, which opposite to that of charges of the impurities are responsible for binding them to sand particles.
4. Biological Action – Biological action due to the development of a film of microorganisms layer on the top of filter media, which absorb organic impurities.

Filtration is carries out in three types of filters

1. Slow sand filter
2. Rapid sand filter Gravity filters
3. Pressure filter

1. SLOW SAND FILTER

Slow sand filters are best suited for the filtration of water for small towns. The sand used for the filtration is specified by the effective size and uniformity coefficient. The effective size, D10,which is the sieve in millimeters that permits 10% sand by weight to pass. The uniformity coefficient is calculated by the ratio of D60 and D10.

CONSTRUCTION

Slow sand filter is made up of a top layer of fine sand of effective size 0.2. to 0.3mm and uniformity coefficient 2 to 3 . The thickness of the layer may be 75 to 90 cm. Below the fine sand layer, a layer of coarse sand of such size whose voids do not permit the fine sand to pass through it. The thickness of this layer may be 30cm. The lowermost layer is a graded gravel of size 2 to 45mm and thickness is about 20 to 30cm. The gravel is laid in layers such that the smallest sizes are at the top. The gravel layer is the retains for the coarse sand layer and is laid over the network of open jointed clay pipe or concrete pipes called under drainage. Water collected by the under drainage is passed into the outlet chamber.

OPERATION

The water from sedimentation tanks enters the slow sand filter through a submersible inlet. This water is uniformly spread over a sand bed without causing any disturbances. The water passes through the filter media at an average rate of 2.4 to 3.6 m3/m2/day. This rate of filtration is continued until the difference between the water level on the filter and in the inlet chamber is slightly less than the depth of water above the sand. The difference of water above the sand bed and in the outlet chamber is called the loss of head. During filtration as the filter media gets clogged due to the impurities, which stay in the pores, the resistance to the passage of water and loss of head also increases. When the loss of head reaches 60cm, filtration is stopped and about 2 to 3 cm from the top of bed is scrapped and replaced with clean sand before putting back into service to the filter. The scrapped sand is washed with the water, dried and stored for return to the filter at the time of the next washing. The filter can run for 6 to 8 weeks before it becomes necessary to replace the sand layer.

USES

The slow sand filters are effective in removal of 98 to 99% of bacteria of raw water and completely all suspended impurities and turbidity is reduced to 1

N.T.U. Slow sand filters also removes odours, tastes and colors from the water but not pathogenic bacteria which requires disinfection to safeguard against water-borne diseases. The slow sand filters require large area for their construction and high initial cost for establishment. The rate of filtration is also very slow.

2. RAPID SAND FILTER

Rapid sand filter are replacing the slow sand filters because of high rate of filtration ranging from 100 to 150m3/m2/day and small area of filter required. The main features of rapid sand filter are as follows.

Effective size of sand - 0.45 to 0.70mm Uniformity coefficient of sand - 1.3 to 1.7

Depth of sand - 60 to75cm Filter gravel - 2 to 50mm size (Increase size towards bottom)

Depth of gravel - 45cm

Depth of water over sand during filtration - 1 to 2m

Overall depth of filter including 0.5m free board - 2.6m Area of single filter unit - 100m2 in two parts of each 50m2 Loss of head - Max 1.8 to 2.0m

Turbidity of filtered water - 1 NTU

CONSTRUCTION

Rapid sand filter consists of the following five parts

1. Enclosure tank – A water tight tank is constructed either masony or concrete
2. Under drainage system – may be perforated pipe system or pipe and stracher system
3. Base material – gravel should free from clay, dust, silt and vegetable matter. Should be durable, hard, round and strong and depth 40cm.
4. Filter media of sand – The depth of sand 60 to 75cm
5. Appurtenances – Air compressors useful for washing of filter and wash water troughs for collection of dirty water after washing of filter. Washing process is continued till the sand bed appears clearly. The washing of filter is done generally after 24 hours and it takes 10 minutes and during back washing the sand bed expands by about 50%.Rapid sand filter bring down the turbidity of water to 1 N.T.U. This filter needs constant and skilled supervision to maintain the filter gauge, expansion gauge and rate of flow controller and periodical backwash.

OPERATION

The water from coagulation sedimentation tank enters the filter unit through inlet pipe and uniformly distributed on the whole sand bed. Water after passing through the sand bed is collected through the under drainage system in the filtered water well. The outlet chamber in this filter is also equipped with filter rate controller. In the beginning the loss of head is very small. But as the bed gets clogged, the loss of head increases and the rate of filtration become very low. Therefore the filter bed requires its washing.

3. PRESSURE FILTER

Pressure filter is type of rapid sand filter in closed water tight cylinder through which the water passes through the sand bed under pressure. All the operations of the filter are similar to rapid gravity filter; expect that the coagulated water is directly applied to the filter without mixing and flocculation. These filters are used for industrial plants but these are not economical on large scale. Pressure filters may be vertical pressure filter and horizontal pressure filter. Backwash is carried by reversing the flow with values. The rate of flow is 120 to 300m3/m2/day.

ADVANTAGES

1. It is a compact and automatic operation
2. These are ideal for small estates and small water works
3. These filters requires small area for installation
4. Small number of fittings is required in these filters
5. Filtered water comes out under pressure no further pumping is required.
6. No sedimentation and coagulant tanks are required with these units.

DISADVANTAGES

1. Due to heavy cost on treatment, they cannot be used for treatment large quantity of water at water works
2. Proper quality control and inspection is not possible because of closed tank
3. The efficiency of removal of bacteria & turbidity is poor.
4. Change of filter media, gravel and repair of drainage system is difficult.

2.4.1 WATER SOFTENING

Water softening is the process of removing hardness. Hardness is defined as the water's ability to consume soap. Besides making water more pleasing for washing purposes, softening water can also provide benefits of preventing encrustation and scaling inside boilers, water heaters, hot-water lines, as well as some industrial processes. Hardness is usually expressed in terms of "ppm as CaCO3", or ppm as calcium carbonate.

The home water softener industry usually measures hardness in the form of grains per gallon, of which 1 gpg equals about 17ppm hardness. The terms, "hard water" and "soft water" are used loosely, as there are no accepted standards or "measuring scale" todetermine if water is soft or hard.

The primary constituents in water that cause hardness are calcium (Ca) and magnesium (Mg), especially calcium. Iron (Fe) and manganese (Mn) can also promote to waterhardness, but typically at a much lesser degree. Hardness caused by calcium and manganese is typically carbonate hardness, for the calcium and manganese exists in the water in the form of calcium bicarbonate, $Ca(HCO_3)_2$, and magnesium bicarbonate, $Mg(HCO_3)_2$. This form of hardness is usually referred to as carbonate hardness, or temporary hardness. On the other hand, the sulfate, chloride and nitrate salts of calcium are usually referred to as permanent hardness, since they cannot be readily precipitated. Water heaters suffer from hard water because when water containing calcium bicarbonate is heated, the insoluble carbonate form of calcium will be precipitated.

It is a property of water, which prevents the lathering of the soap. Hardness is of two types.

1. Temporary hardness: It is caused due to the presence of carbonates and sulphates of calcium and magnesium. It is removed by boiling.
2. Permanent hardness: It is caused due to the presence of chlorides and nitrates of calcium and magnesium. It is removed by zeolite method.

Hardness is usually expressed in gm/liter or p.p.m. of calcium carbonate in water. Hardness of water is determined by EDTA method. For potable water hardness ranges from 5 to 8 degrees.

Temporary hardness removal methods:

Boiling of Water:

Calcium carbonate – slightly soluble in water – present in the form Calcium bicarbonate because, it easily dissolves in water containing CO_2.

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

Addition of Lime (CaO):

Hydrated lime [Ca(OH)2] is added to water

$$MgCO_3 + Ca(OH)_2 \quad Mg(OH)_2 + CaCO_3$$

$$Mg(HCO_3)_2 + Ca(OH)_2 \quad Ca(HCO_3)_2 + Mg(OH)_2$$

$$Ca(HCO_3)_2 + Ca(OH)_2 \quad 2CaCO_3 + 2H_2O$$

Suitable only for Temporary hardness removal process.

Permanent hardness removal methods

1. Lime-Soda process
2. Base-Exchange process, generally called *Zeolite process*
3. Demineralization process

1. Lime-Soda process

Lime soda process is a method of softening hard water. This process is now obsolete but was very useful for the treatment of large volumes of hard water. In this process Calcium and Magnesium ions are precipitated by the addition of lime (Ca(OH)2) and soda ash (Na2CO3).

Chemistry of Lime Soda Process:

Lime addition removes only magnesium hardness and calcium carbonate hardness. In equation 5 magnesium is precipitated, however, an equivalent amount of calcium is added. The water now contains the original calcium noncarbonate hardness and the calcium non-carbonate hardness produced in equation 5. Soda ash is added to remove calcium non-carbonate hardness:

$$Na_2CO_3 + CaSO_4 \text{--------} Na_2SO_4 + CaCO_3$$

Limitations of Lime Soda Process

Lime soda softening cannot produce a water at completely free of hardness because of minute solubility of $CaCO_3$ and Mg $(OH)_2$. Thus the minimum calcium hardness can be achieved is about 30 mg/L as $CaCO_3$, and the magnesium hardness is about 10 mg/L as $CaCO_3$.

We normally tolerate a final total hardness on the order of 75 to 120 mg/L as $CaCO_3$, but the magnesium content should not exceed 40 mg/L as $CaCO_3$.

2. Base-Exchange process, generally called *Zeolite process*

Zeolite or Base-Exchange or Cation exchange process

Zeolites are of two types:

1. Natural zeolite : Natural zeolite are non-porous. for example,natrolite ,$Na_2O.Al_2O_3.xSiO_2.yH_2O$.

2. Synthtic zeolite : Synthtic zeolite are porous and posses get structure. They are prepared by heating together china clay,feldspar and soda ash. Such zeolites possess higher exchange capacity per unit weight than natural zeolites.

Zeolite – termed as *Green sand* – Na2O Al2O3 x.SiO2 y.H2O

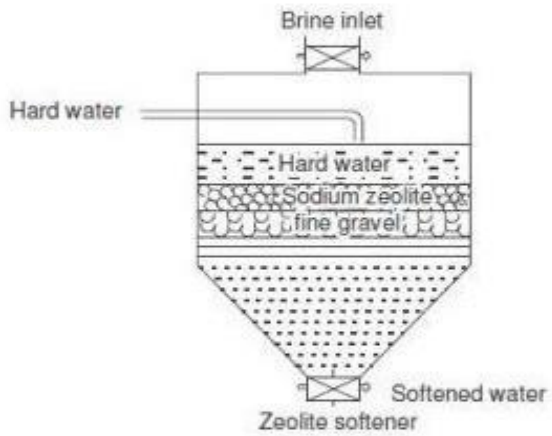
Zeolite or Resins have excellent property of exchanging their cations and hence during softening operation, the sodium ions of the zeolite get replaced by the calcium and magnesium ions present in hard water.

Used as filter media in sand filter (Zeolite sand bed)

• When Sodium is replaced by Calcium & Magnesium – backwashing is done – Again brine is added to regenerated the filter bed – excess brine is removed by back washing with water

• Filters – Gravity or Pressure (more common)

• Rate of filtration: 300 l/m2/min



• Zeolite process results in *Zero hardness* – not suitable for public supplies – small amount is processed and mixed with un softened water to obtain standard limits.

2.4.2 REMOVAL OF IRON

Iron and manganese removal:

Iron and manganese control is the most common type of municipal water treatment. Iron and manganese occur naturally in groundwater. These elements are in fact, essential to the human diet. Water containing excessive amounts of iron and manganese can stain clothes, discolor plumbing fixtures, and sometimes add a"rusty" taste and look to the water. Surface water generally does not contain large amounts of iron or manganese, but iron and manganese are found frequently in water systems that use ground water. Iron In drinking water is 0.3 parts per million (ppm) and 0.05 ppm for manganese.

- Iron and manganese minerals are found in soil and rock.
- Iron and manganese can dissolve into groundwater as it percolates through the soil and rock.
- more than 0.3 mg/l of iron will cause yellow to reddish-brown stains of plumbing fixtures or almost anything that it contacts.
- Manganese even at levels as low as 0.1 mg/l, will cause blackish staining of fixtures and anything else it contacts.
- If the water contains both iron and manganese, staining could vary from dark brown to black.
- Iron and manganese in well waters occur as soluble ferrous and manganous bicarbonate.

IRON AND MANGANESE REMOVAL BY AERATION:

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- Iron and manganese in well waters occur as soluble ferrous and manganous bicarbonates.

Iron and Manganese Removal by Filtration:

Removing iron and manganese from drinking water instead of sequestration it is recommended if the water contains over 0.3 ppm of iron or 0.05 ppm of manganese. These elements can be removed during softening with lime, but most commonly iron and manganese is removed by filtration after oxidation (with air, potassium permanganate, or chlorine).

Gravity and pressure filters are both used, with pressure filters being the more popular. The operator should frequently check to see that all the iron in the water entering the filter has been converted to the ferric (or insoluble particulate) state. The operator collects a water sample, passes it through a filter paper, and runs an iron test on the clean, filtered water (filtrate).

If no iron is present, it has all been oxidized and is being removed in the filtration process. If iron is found in the filtrate, oxidation has not been complete and some of the iron will pass through the filter and end up in the treated water. In this case, the operator should consider adjustments to the oxidation process.

Most iron removal filters are designed so that the filters are backwashed based on head-loss on the filter. If iron breakthrough is a problem, the filters will have to be backwashed more frequently. Accurate records will reveal when breakthrough is expected so that the operator can backwash before it is likely to occur.

2.5 DESALINATION

Desalination is a process that extracts minerals from saline water. More generally, desalination refers to the removal of salts and minerals from a target substance, as in soil desalination, which is an issue for agriculture. Water is one of the earth's most abundant resources, covering about three-quarters of the planet's surface. The reason for this apparent contradiction is, of course, that 97.5% of the earth's water is salt water in the oceans and only 2.5% is fresh water in groundwater, lakes and rivers and this supplies most human and animal needs. The process of removing dissolved salts from water, thus producing fresh water from seawater or brackish water.

Methods of Desalination

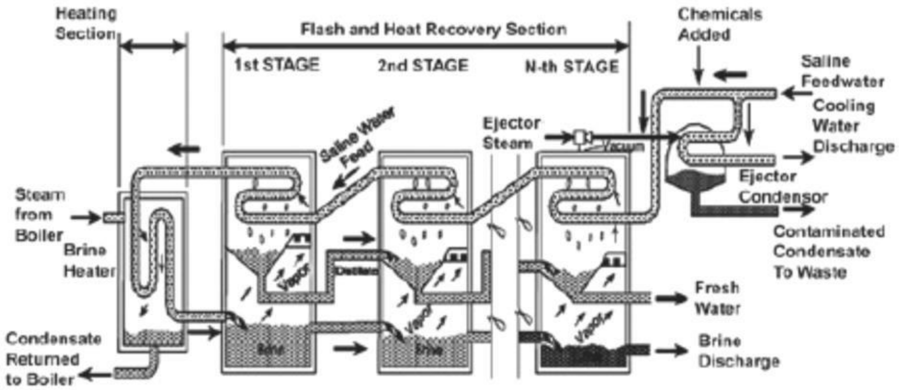
1. Desalination by evaporation & distillation
2. Electro dialysis method
3. Reverse Osmosis method
4. Freezing process
5. Solar distillation method

1. Desalination by evaporation & distillation:

Thermal desalination, often called distillation, is one of the most Thermal most ancient ways of treating seawater and brackish water to convert them ancient them into potable water. It is based on the principles of boiling or into or evaporation and condensation. Water is heated until it reaches the evaporation the evaporation state. The salt is left behind while the vapor is evaporation condensed to produce fresh water.

In this process, the liquids are separated by evaporating and capturing them at various points in their cooling cycle, and then immediately channeled into a condenser.

•Simple distillation is used for a mixture in which the boiling point of the components differ by at least 158°F (70°C).

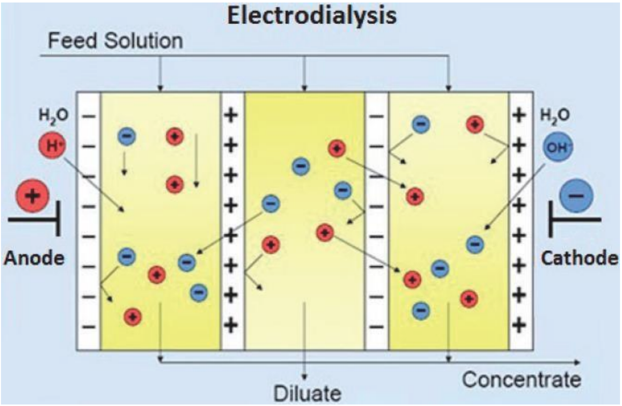


•It is also followed for the mixtures contaminated with nonvolatile particles (solid or oil), and those that are nearly pure with less than 10 percent contamination.

2. Electro dialysis method:

Electrodialysis desalination process is in some way similar to "ion exchange"treatment process, but it differs in utilizing both cation and anion selective membranes to separate charged ions.

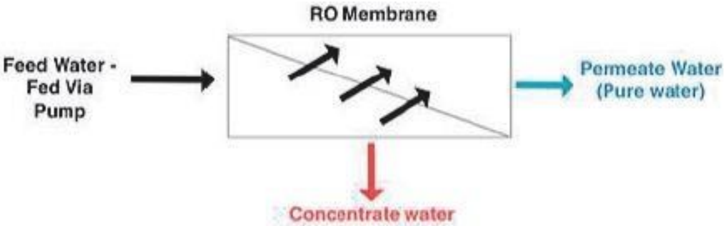
Electrodialysis (ED) is used to transport salt ions from one solution through ion-exchange membranes to another solution under the influence of an applied electric potential difference.



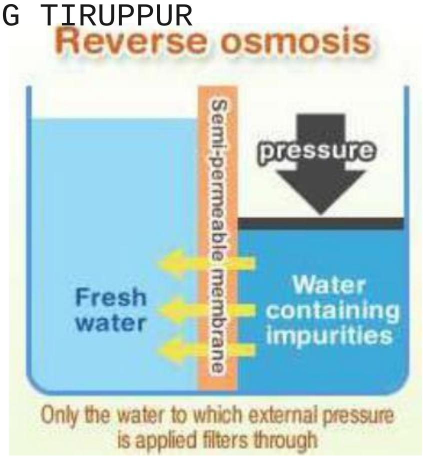
Water is handed between a negative electrode and a high-quality electrode. Ion exchange membranes permit solely high-quality ions to transfer toward the negative electrode from the feed water and negative ions to the positive electrode.

3. Reverse Osmosis method:

Reverse osmosis (RO) membrane is known as hyper filtration and is the supreme filtration known. Reverse osmosis allows the removal of small particles and dissolved organic matter. It is also employed to purify different fluids including glycol and ethanol, rejecting other ions and contaminants preventing them from passing through the membrane. Reverse osmosis is commonly used in water treatment.



Reverse osmosis membrane is a semipermeable membrane allowing fluid that is to be purified to permit through the membrane and rejecting contaminants in the reject stream. Most reverse osmosis systems use cross flow mechanism to decrease membrane cleaning periods. As the fluid flows through the reverse osmosis membranes, the downstream, remove the reject away from in concentrated reject water (brine).



When a semipermeable membrane is used to separate two water (or other solvent) volumes, water is going to flow from the low solute concentration side to the high solute concentration side. By applying an external pressure on the higher concentration side, the flow could be stopped or reversed. In such a case, the phenomenon is called "reverse osmosis." If there are solute molecules only on one side of the system, then the pressure that stops the flow is called the osmotic pressure. The movement of a "solute molecule" within a solvent is over damped by the solvent molecules that surround it.

4. Freezing process:

The basic principles of freezing desalination are simple. During the process of freezing, dissolved salts are excluded during the formation of ice crystals. Seawater can be desalinated by cooling the water to form crystals under controlled conditions. Before the entire mass of water has been frozen, the mixture is usually washed and rinsed to remove the salts in the remaining water or adhering to the ice crystals. The ice is then melted to produce fresh water.

Advantages and disadvantages:

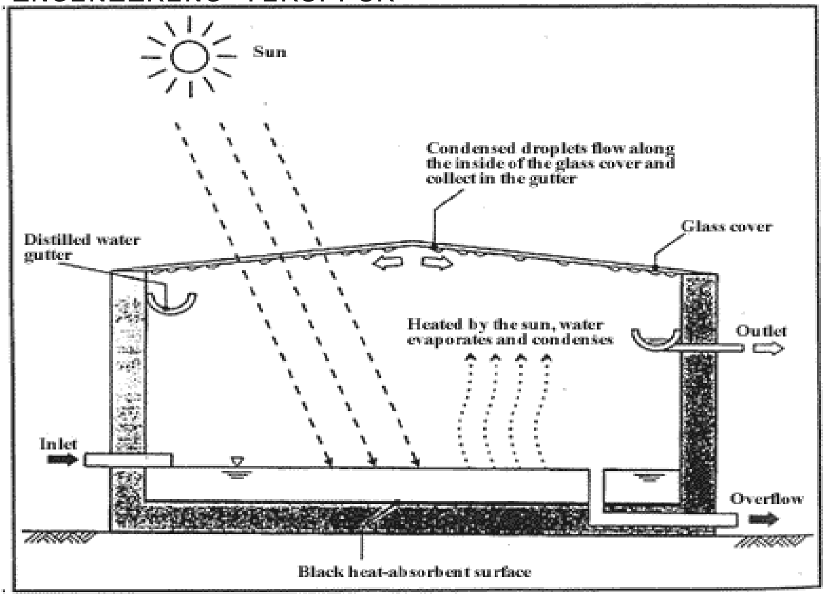
The advantages include a lower theoretical energy requirement, minimal potential for corrosion and little scaling or salt precipitation.

It can produce very pure potable water, and it has special advantages to produce water for irrigation.

The disadvantage is that it involves handling ice and water mixtures that are mechanically complicated to move and process

5. Solar distillation method:

Solar desalination using humidification and dehumidification is a promising technique for producing fresh water, especially in remote and sunny regions. It has the potential to make a significant contribution to providing humans with fresh water using a renewable, free and environmentally friendly energy source.Solar energy can be used to convert saline water into fresh water with simple, low cost and economical technology and thus it is suitable for small communities, rural areas and areas where the income level is very low.


Sun
Condensed droplets flow along the inside of the glass cover and collect in the gutter
Glass cover
Distilled water gutter
Heated by the sun, water evaporates and condenses
Outlet
Inlet
Overflow
Black heat-absorbent surface

2.5.1 RO PROCESSES

Membrane Processes:

Membrane Processes are becoming popular because they are considered "Green" technology - no chemicals are used in the process. A membrane is a selective barrier that permits the separation of certain species in a fluid by combination of sieving and diffusion mechanisms. Membranes can separate particles and molecules and over a wide particle size range and molecular weights.

Four common types of membranes:

- Reverse Osmosis
- Nano filtration
- Ultra filtration
- Micro filtration

The R.O. membrane is semi-permeable with thin layer of annealed material supported on a more porous sub-structure.

- The thin skin is about 0.25 micron thick and has pore size in the 5 – 10 Angstrom range.
- The porous sub-structure is primarily to support the thin skin. The pore size of the skin limits transport to certain size molecules.
- Dissolved ions such as Na and Cl are about the same size as water molecules.

However, the charged ions seem to be repelled by the active portion of the membrane and water is attracted to it.

- So adsorbed water will block the passage and exclude ions.
- Under pressure attached water will be transferred through the pores.

Nanofiltration is a complementary process to reverse osmosis, where divalent cations and anions are preferentially rejected over the monovalent cations and anions.

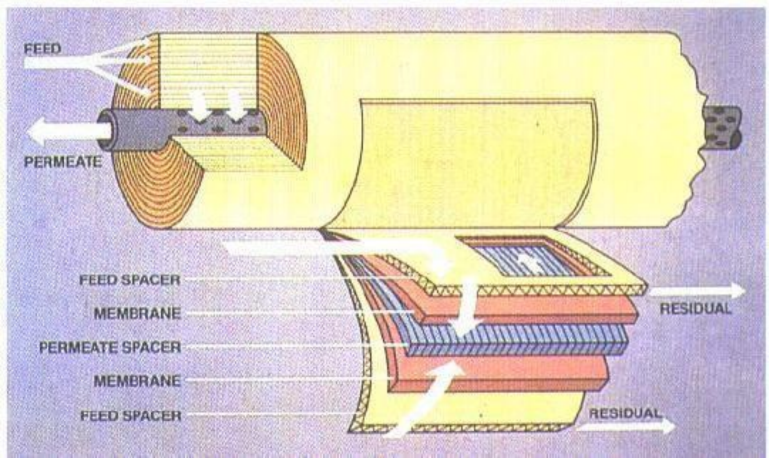
- Some organics with MW > 100 -500 are removed There is an osmotic pressure developed but it is less than that of the R.O. process.

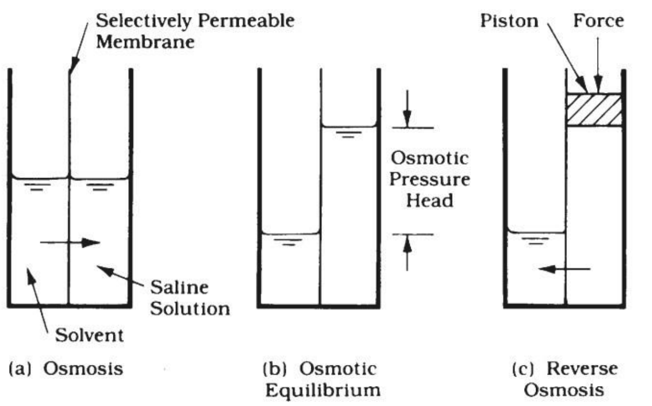
Microfiltration and Ultra filtration are essentially membrane processes that rely on pureIf clean water and water with some concentration of solute are separated by a semi-permeable membrane (permeable to only water) water will be transported across the membrane until increases hydrostatic pressure on the solute side will force the process to stop.

•straining through porosity in the membranes.

•Pressure required is lower than R.O. and due entirely to frictional head loss

Spiral-Wound Membrane Element





The osmotic pressure head (at equilibrium) can be calculated from thermodynamics. Thechemical potential (Gibbs frees energy per mole) of the solvent and the solute(s) in any phase can be described as:

Applications of Micro- and Ultra filtration Conventional water treatment (replace all processes except disinfection).

•Pretreat water for R.O and nanofiltration.

•Iron/Manganese removal (after oxidation).

Applications for R.O. and nanofiltration:

•R.O. application mostly desalination.

•Nanofiltration first developed to remove hardness.

Comparison of Membrane process:

Ultrafiltration	Reverse Osmosis	Microfiltration
Operates on difficult colloidal water	Requires extensive pre-treatment of colloids	Rapidly fouled by colloids giving high replacement costs
Low pressure (2-6 bar)	High pressure (10-30 bar)	Low pressure (2-4 bar)
Low energy consumption	High energy	Low energy
High recovery (up to 95%)	Low recovery (50-80%)	100% recovery
Chemical tolerance pH 1-13	pH 2-11	pH 1-13
High temperature up to 80^{o}C	45^{o}C max.	High temperatures possible
High resistance to oxidising agents	Limited resistance to oxidising agents	High resistance to oxidising agents
Stream sterilisable membranes available	Stream sterilisation not possible	Stream sterilisation possible
Hygienic module designs available	Modules not as hygienic	Hygienic designs available

3.1 APPURTENANCES IN THE DISTRIBUTION SYSTEM

Appurtenances are fitted in the pipe network and distribution system f or its efficient and controlled functioning.

The following are some appurtenances of distribution system:

1. Fire hydrants
2. Water meters
3. Water taps
4. Stop cocks
5. Pipe bends

FIRE HYDRANTS:

A Hydrant is an outlet provided in water distribution main or a sub-main for tapping water mainly during fires and sometimes used for withdrawing water for Filling the municipal water tankers.

During fire breakout, a nearby hydrant is connected to the fire hose, and water obtained from the hydrant is used to extinguish the fire.

Fire hydrants are used so as to obtain the water at high rates and also to make it reach several storeyed high buildings, such pressures are generally developed by attaching fire hydrants outlet to the fire engine.

REQUIRMENTS OF GOOD HYDRANTS:

i. It should be such as to connect the hose or the motor pump easily to it.

ii. It should be cheap.

iii. It should be easily detectable during the panicky atmosphere of fire.

iv. It should not get out of order during the operation.

v. On being fully opened it should allow undisturbed water f low.

TYPES OF FIRE HYDRANTS

1) Post Fire Hydrants

2) Flush Fire Hydrants

1) Post Fire Hydrants:

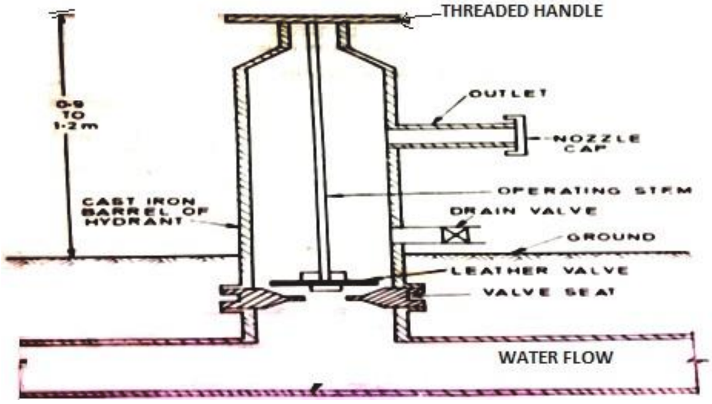
The post fire hydrant remains standing above the ground like a post by about 0.9 to 1.2m.It can be detected very easily as they project above the ground. They are liable to be damaged by children and mischief mongers. They are widely used in countries like America, because of the greater civic sense prevailing there.

Parts of Post Fire Hydrants

❒ Cast iron barrel of hydrants

Valve stem- Leather valve at lower end, top end connected to the nut

- Valve seat
- Drain valve
- Outlet pipe-with nozzle cap a t he periphery of the hydrant barrel



Working

In closed position the leather valve rest at valve seat, for opening the hydrat the nut is operate so as to raise the leather valve up, thereby admitting the water in to the hydrant barrel. The outlet at the periphery of the hydrant carries the water to the location through hose pipe.

- Outlet diameter:
- 63 mm diameter outlets: when boosting of pressure is not required
- 100 mm diameter outlets: when boosting of pressure is required for connecting it to fire engine or pumps.

2) Flush Fire Hydrants

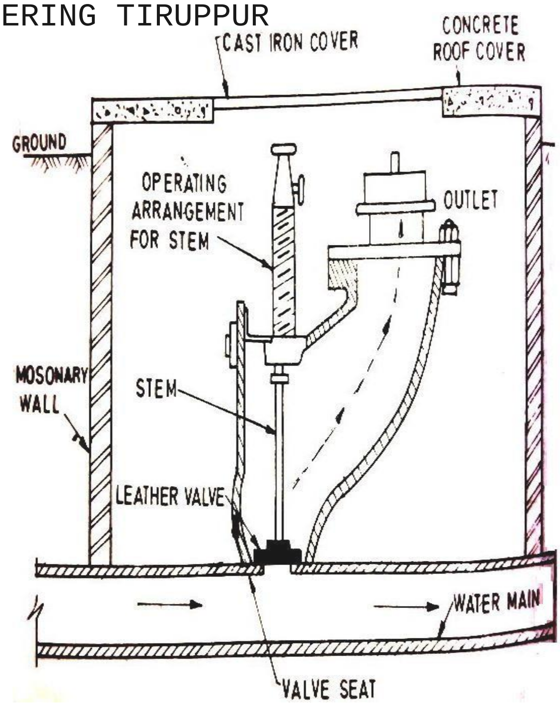
It is installed underground in a brick or cast iron chamber with its top cover slightly above the street level. Under the panicky circumstances during fire, it is difficult to search the flush fire hydrants. They are less prone to damage by mischievous people.

Parts of Flush Fire Hydrants

- Masonry wall
- Cast iron cover
- Concrete roof cover
- Valve stem
- Leather valve
- Outlet

Working

There is only one outlet opening on the side of the moving stem. The same opening may be directly connected to the hose pipe or may be connected to the fire engine.



WATER METES:

Water meters are the devices which are used for measuring the quantity of water flowing under pressure through a pressure conduit. The measurement of quantity of water supplied to the general public is necessary, in order to charge the consumers according to the quantity of water supplied to them.

Requirements of good Water Meters

- It must record the entire water passing through it.
- Its maintenance and repair should be easy.
- It should measure the discharge within the maximum limit of 20% error.
- It should be able to work efficiently at all pressures in the mains.
- It should cause minimum hindrance to the flow and therefore cause minimum head Loss in working.
- Its parts should not be easily affected by the chemicals present in the water passing through it.
- It should prevent the back flow passing through it and should not be liable to clogging.

Types of Meters

- Velocity meters or the inferential meters.
- Positive meters or the Displacement meters.

1) VELOCITY METERS OR THE I NFERENTIAL METERS

- It measures the horizontal velocity of water flowing through them.
- It can be successfully used f or measuring high flows.
- Generally used f or measuring supplies to industries and trades

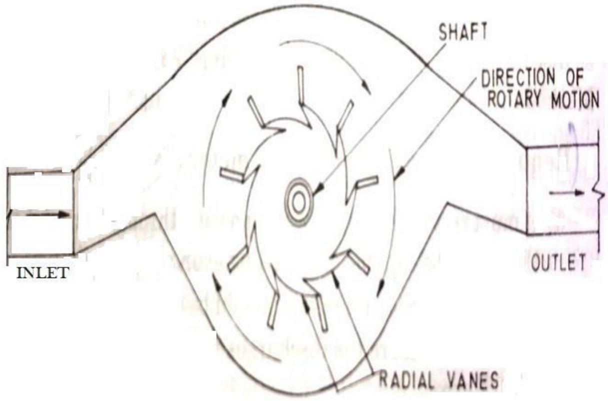
- They are available in smaller sizes up to 20 mm; therefore it is also used for measuring small domestic supplies.
- Their accuracy is less when compared to displacement meters

Examples of velocity meters:

- Rotary meters
- Turbine meters
- Venturimeter

Rotary meters:

- It consists of radial vanes attached to the shaft and enclosed in the casing.
- When water entering with certain velocity passes through the meter , the radial vanes are rotated in clockwise direction.
- The number of revolutions per unit time depends upon the velocity of flow.
- The greater the velocity the higher will be the speed of rotation.
- The discharge is proportional to the speed of the shaft.



The meter can hence be calibrated to directly read the discharge.

Turbine meters:

- It is similar to rotary meter.
- It consists of turbine wheel which is rotated by moving water.
- The number of revolutions made by turbine wheel will give the discharge as in rotary meters.

Venturi-meter:

- It works based on the principle of Bernoulli's equation.
- It is preferably used to measure high flows in large pipes with nominal head loss.
- It is not suitable to measure small flows.
- The venturi-meter consists of gradually contracting the normal pipe to the throat section and then expanding to normal size.
- Piezometers are inserted at normal end and throat section.
- The discharge through pipe is proportional to the difference of head between two piezometers
- It measures the head difference (H-h) and then integrates the discharge over any period of time.

Stop cocks:

- Screw down type valve used for stopping and opening water supply
- Generally provided before the water enters the water meter
- Also provided inside the building

3.2 PIPE FITTINGS

Pipe appurtenances are components attached in pipe line which aid in proper functioning of pipe network. Role of appurtenances are ceasing, controlling, diversion and regulating flows through the pipe network.

The necessities of the various appurtenances in distribution system are as follows

1. To control the rate of flow of water

2. To release or admit air into pipeline according to the situation

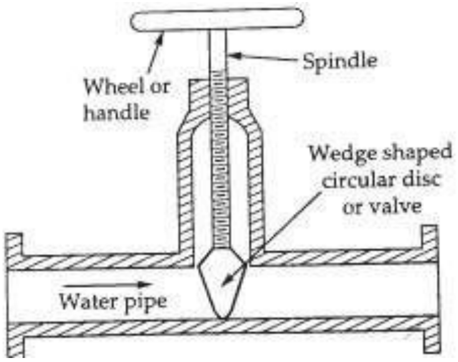
3. To prevent or detect leakages

4. To meet the demand during emergency and

5. Ultimately to improve the efficiency of the distribution.

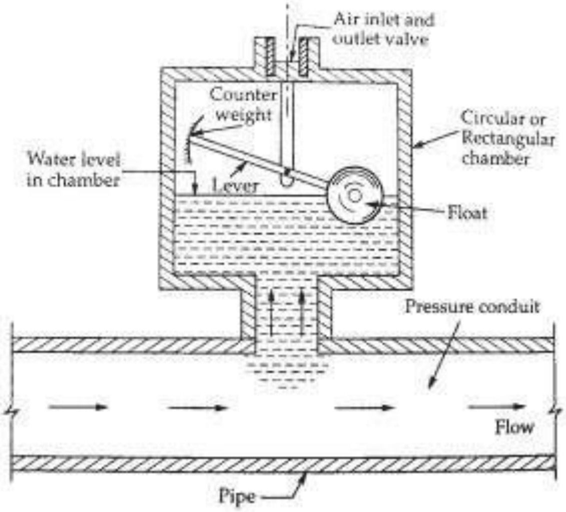
Sluice valve or gate valve:

These are also known as shut off valves or stop valves. They are extensively used in the distribution system to shut off the supplies whenever desired. they are also helpful in dividing the water mains into suitable sections. The spacing of such valves may between 150 to 300 meters. They are also placed at street corners or where two pipe lines intersect. they posses the advantage over most other types of valves, of combining relatively low cost and offering almost no resistance to f low of water when the valve is wide open.



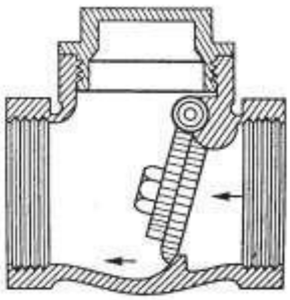
Air relief valves:

The water flowing through the pipe lines always contain some air. This air rises to accumulate at high points, and may interfere with flow. Air valves are also required to discharge air when a main is being filled and to admit air when it is being emptied. The admission of air on emptying the main is of great importance on steel mains, which may flatten if the pressure falls below that of the atmosphere.



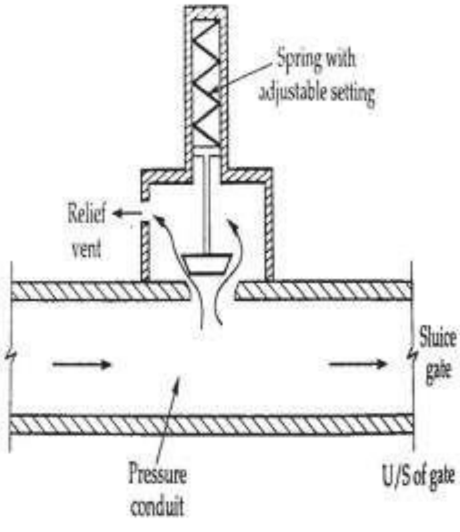
Reflux valves:

Reflux valves are also known as check valves or non-return valves. It is automatic device which allows water to flow in one direction only. They are placed in water pipes which obtain water directly from the pump. When the pump is stopped ,the water in the pipeline does not rush back and damage the pump.



Pressure relief valves

These are also known as automatic cutoff valves or safety valves. They are located at those points where pressure is likely to be maximum. When the line pressure increases above the pre-set valve operates automatically and the pressure is reduced.



Scour valves:

Scour valves or blow off valves or washout valves are ordinary sluice valves that are located either at the dead ends or at lowest points in the mains. They are operated to blow off or remove the sand and silt deposited in the pipe line. They are operated manually.

3.2.1 PUMPS

The function of pump is to leave the water or any fluid to higher elevation or at higher pressure. Pumps are driven by electricity, diesel or steam power. They are helpful in pumping water from the sources that is from intake to the treatment plant and from treatment plant to the distribution system or service reservoir. In homes also pumps are used to pump water to upper floors or to store water in tanks over the buildings. Based on the mechanical principle of water lifting pumps are classified as the Following

CENTRIFUGAL PUMPS

Centrifugal force is made use of in lifting water. Electrical energy is converted to potential or pressure energy of water.

COMPONENT PARTS OF CENTRIFUGAL PUMP

Centrifugal pump consists of the following parts

1. Casing: The impellor is enclosed in the casing, which is so designed that kinetic energy of the liquid is converted into pressure energy before it leaves the casing.

2. Delivery pipe

3. Delivery valve

4. Impeller

5. Prime mover

6. Suction pipe

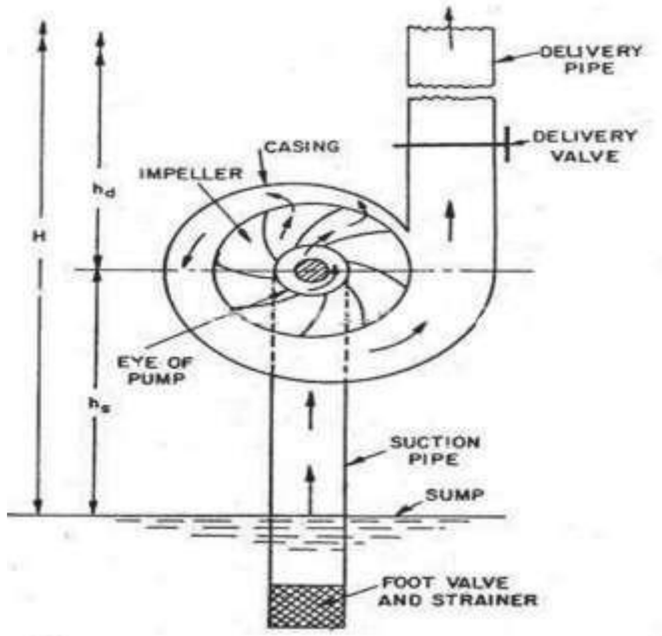
7. Strainer and foot valve

DESCRIPTION

The pump consists of a Impeller is enclosed in a water tight casing. Water at lower level is sucked into the impellor through a suction pipe. Suction pipe should be air tight and bends in this pipe should be avoided. A strainer foot valve is connected at the bottom of the suction pipe to prevent entry of foreign matter and to hold water during pumping . Suction pipe is kept larger in diameter than delivery pipe to reduce cavitations and losses due to friction. An electric motor is coupled to the central shaft to impart energy.

WORKING PRINCIPLE

When the impellor starts rotating it creates reduction of pressure at the eye of the impellor, which sucks in water through the suction pipe. Water on entering the eye is caught between the vanes of the impeller. Rapid rotation of the impellor sets up a centrifugal force and forces the water at high velocity outwards against the causing convert the velocity energy into pressure energy which is utilized to overcome the delivery head



OPERATION AND MAINTENANCE

Priming – Priming means filling up of the suction and casing completely with water. Pressure and suction developed by the impellor is proportional to the density of the fluid and the speed of rotation. Impellor running in air will produce only negligible negative pressure on the head. Hence it is required that is the casing and impellor is filled with water through a funnel and cock. Trapped air is released through pet cock. Initially the delivery valve is closed and the pump started. The rotation impellor pushes the water in the casing into the delivery pipe and the water in the casing into the delivery pipe and the resulting vacuum is filled by water raising through the suction pipe. The pass valve is opened while closing the bypass valve , while stopping the pump delivery valve is closed first and the pump switched off. Maintenance may be

1) Preventive maintenance 2) Break down maintenance.

Preventive maintenance

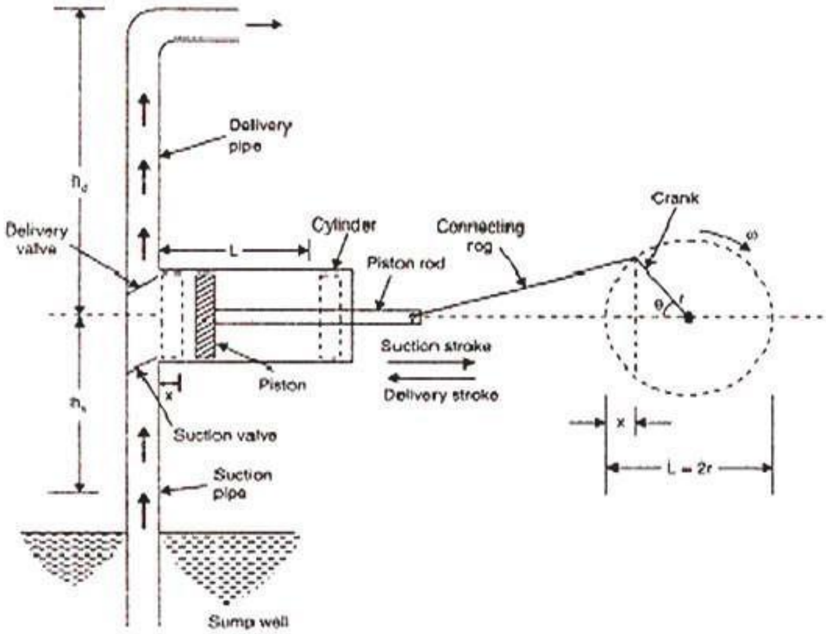
Locates the sources of trouble and keep the equipment in good operating condition. It involves oiling, greasing of stuffing boxes, observing the temperature of the motor and the pump bearings, checking the valves, strainer, electrical contacts, earthings etc.

Break down maintenance

Involves replacement of worn out components and testing . Sufficient amount of spares of impellors, bearings, slip-ring brushes, stater-contacts, gland packing, greases, oils, jointing materials, valves are to be kept in stock to attend to the emergencies. It is usual to have one stand by pump in addition to the required number of pumps.

RECIPROCATING PUMP

- A reciprocating pumps consists of a plunger or a piston that moves forward and backward inside a cylinder with the help of a connecting rod and a crank. The crank is rotated by an external source of power.
- The cylinder is connected to the sump by a suction pipe and to the delivery tank by a delivery pipe.
- At the cylinder ends of these pipes, non-return valves are provided. A non-return valve allows the liquid to pass in only one direction.
- Through suction valve, liquid can only be admitted into the cylinder and through the delivery valve, liquid can only be discharged into the delivery pipe.



Working of Reciprocating pump

- When the piston moves from the left to the right, a suction pressure is produced in the cylinder. If the pump is started for the first time or after a long period, air from the suction pipe is sucked during the suction stroke, while the delivery valve is closed. Liquid rises into the suction pipe by a small height due to atmospheric pressure on the sump liquid.
- During the delivery stroke, air in the cylinder is pushed out into the delivery pipe by the thrust of the piston, while the suction valve is closed. When all the air from the suction pipe has been exhausted, the liquid from the sump is able to rise and enter the cylinder.
- During the delivery stroke it is displaced into the delivery pipe. Thus the liquid is delivered into the delivery tank intermittently, i.e. during the delivery stroke only.

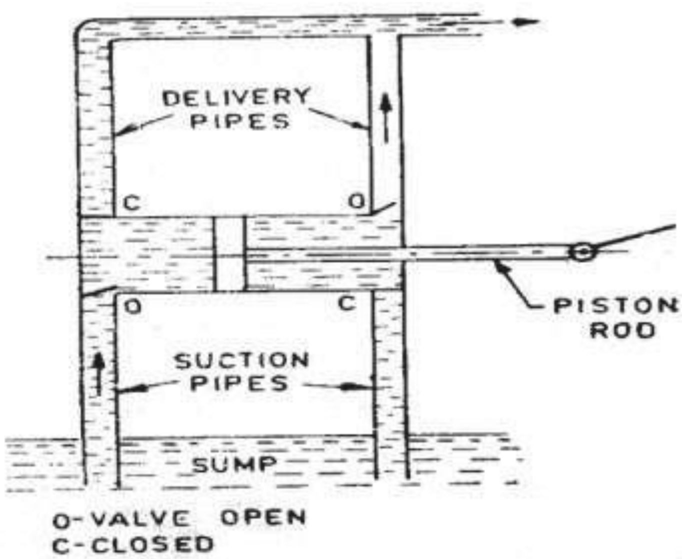
Following are the main types of reciprocating pumps:
According to use of piston sides:

- Single acting Reciprocating Pump:

If there is only one suction and one delivery pipe and the liquid is filled only on one side of the piston, it is called a single-acting reciprocating pump.

- Double acting Reciprocating Pump:

A double-acting reciprocating pump has two suction and two delivery pipes, Liquid is receiving on both sides of the piston in the cylinder and is delivered into the respective delivery pipes.



Double-acting reciprocating pump

AIR LIFT PUMP

Its main function is to lift water from a deep well or sump by using compressed air. By buoyancy the air, which has a lower density than the liquid, rises quickly. By fluid pressure, the liquid is taken in the ascendant air flow and moves in the same direction as the air.

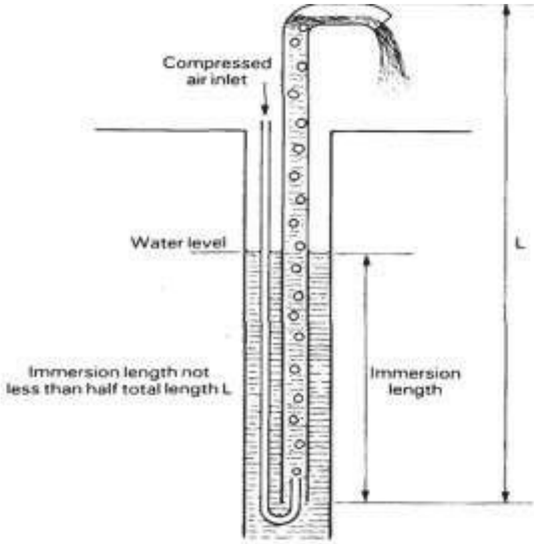
The main components are:

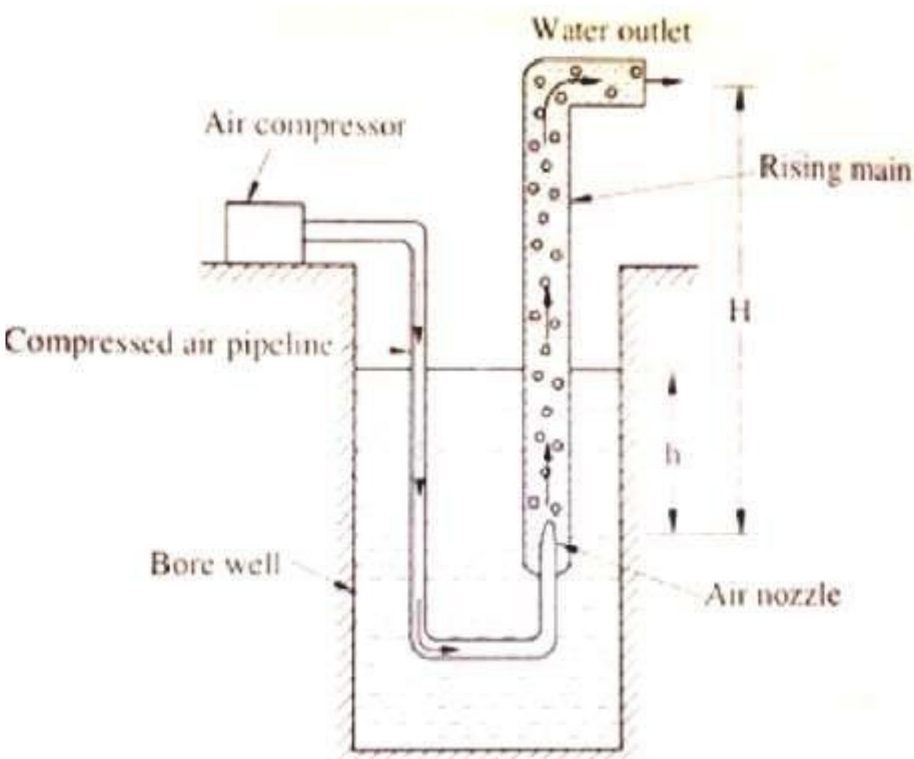
1. Air compressor to supply compress air
2. Air pipe fitted with one or more nozzles
3. Delivery pipe

The lower portion of delivery pipe dips into well and water gets discharge from the upper end of the delivery pipe.

Working:

The compressed air from compressor is bottom end of delivery pipe through air pipeline as a fine spray. Then, air gradually mixes with water in delivery pipe, so from that inside the delivery pipe density of air - water mixture decease. As soon as pressure in delivery pipe of height H becomes less than the pressure due to the height of water column h in outlet of the delivery pipe. As per this reason rising begins in the delivery pipe above the level of water outside the delivery pipe. And other reason that the water in delivery pipe lighter than outside of the delivery pipe.





Advantages:

The air lift pump is not having any moving parts below water level and hence there are no chances of suspended solid particles damaging the pump.

This pump can raise water through a bore hole of given diameter than any other pump.

This pump is very suitable where decompressed air is available.

Disadvantages:

Conventional airlift pumps have a flow rate that is very limited.

Very low efficiency, only 20 to 40% energy available in form of useful water horse-power.

It cannot lift water when the level of water in deep well goes down below limit.

The suction is limited.

Application:

Airlift pumps are often used in deep dirty wells where sand would quickly abrade mechanical parts.

It is also sometimes used in part of the process on a wastewater treatment plant if a small head is required (typically around 1 foot head).

POINT TO BE OBSERVED IN SELECTING A PUMP

1. Capacity and efficiency - The pump should have the capacity required and optimum efficiency.

2. Lift - Suction head from the water level to the pump level

3. Head – It is also called delivery head. Generally the total head (suction and delivery head) should meet all possible situations with respect to the head.

4. Reliability – A reputed manufacture or similar make pump already in use may give the failure rate and types of troubles.

5. Initial cost: The cost of the pump and its installation cost should be minimum.

6. Power – Power requirements should be less for operation

7. Maintenance – Maintenance cost should be minimum. Availability of spares and cost of spares are to be ascertained.

3.2.2 PIPE CORROSION

CAUSES AND PREVENTION:

The term pipe corrosion is used to indicate the loss of pipe material due to action of water (Internal pipe corrosion) and action of water logged soil above the pipe surface (external pipe corrosion) by the results of corrosion, troublesome to both the water authority and consumers. The various factors contributing to the pipe corrosion are

1. ACIDITY: The water having low PH value due to the presence of carbonic acid or other acids may cause corrosion

2. ALKANITY: The water possessing sufficient calcium bicarbonate alkanilinity is anti-corrosive in nature

3. BIOLOGICAL ACTION: The growth of iron-bacteria, and sulphur bacteria may develop aerobic and anaerobic corrosion respectively.

4. CHLORINATION: The presence of free chlorine or chloramines makes the water corrosive

5. ELECTRICAL CURRENTS: Corrosion canals also be developed by the union of dissimilar metals or by the earthing of electrical system to water pipes.

6. MINERAL AND ORGANIC CONSTITUENTS: The presence of high total solids in water accelerates the process of corrosion

7. OXYGEN: the presence of oxygen is found in both the corrosive and non-corrosive waters. The aeration infact is employed in some cases for prevention of corrosion.

EFFECTS OF PIPE CORROSION

1. Pipe corrosion may lead to the tuberculation (formation of small projections on the inside surface of pipe) which decreases carrying capacity of water

2. The pipe corrosion leads to the disintegration of pipeline and it demands heavy repairs

3. The pipe corrosion imparts colour, taste and odour to the flowing water

4. The pipe connections are seriously affected by pipe corrosion

5. The pipe corrosion may make the water dangerous for drinking and other purposes.

PREVENTION OF PIPE CORROSION

Pipe corrosion is not possible to completely eliminate but we can minimize by the following methods.

1. Cathodic protection: By connecting the pipe line to the negative pole of D.C. generator or to the anode metals like magnesium so that the entire pipe acts as cathode. This cathodic treatment is most effective. It is expensive and involves many practical problems

2. Proper pipe material: The alloys of Iron or steel with cromium, copper or nickel are found to be more resistance

3. Protective Linings: The pipe surface should be coated with asphalt, bitumen, cement mortar, paints, resins, tar, zinc etc.

4. Treatment of water: By proper treatment and adjustment of PH value, control of calcium carbonate, removal dissolved oxygen and carbon dioxide, addition of sodium silicate etc prevent the pipe corrosion.

3.3 PIPE MATERIALS

Pipes convey raw water from the source to the treatment plants in the distribution system. Water is under pressure always and hence the pipe material and the fixture should withstand stresses due to the internal pressure, vaccum pressure, when the pipes are empty, water hammer when the values are closed and temperature stresses.

Requirements of pipe material:

1. It should be capable of withstanding internal and external pressures
2. It should have facility of easy joints
3. It should be available in all sizes, transport and erection should be easy.
4. It should be durable
5. It should not react with water to alter its quality
6. Cost of pipes should be less
7. Frictional head loss should be minimum.
8. The damaged units should be replaced easily.

Pipeline materials:

1. Cast iron
2. Wrought iron
3. Steel
4. Galvanized iron
5. Cement concrete
6. Asbestos cement
7. Plastic
8. Copper
9. Lead

1. Cast iron pipe

Cast iron pipes are used i n great majority of water in distribution mains because of centuries of satisfactory experience with it. Cast –iron pipe is resistant to corrosion and accordingly is long lived –its life may be over 100 years. Cast iron pipes are manufactured by two methods (i) ordinary sand moulding process (ii) centrifugal process.

Advantages of C.I pipes

- C.I pipes are of moderate cost.
- Their jointing is easier.
- They are resistant to corrosion
- They have long life.

Dis -advantages

- They are subject to tuberculation in certain waters, due to which their carrying Capacity is reduced to as much as 70%.
- They are heavier and hence uneconomical when their diameter is more than 120cm.
- They cannot be used for pressures greater than 7 Kg/cm2
- They are fragile.

2. Wrought iron pipe

Wrought iron pipes are manufactured by rolling flat plates of the such pipes are much lighter than the C.I pipes and can be more easily cut , threaded and worked. They look much neater, but are much costlier.

3. Steel pipes

Steel pipes of small diameter can be made from the solid, but the larger sizes are made by riveting together the edges of suitably –curved plates, the sockets being formed later in a press. The joints may be either transverse or longitudinal or transverse and spiral.

4. Galvanized Iron pipes

- The pipes are cheap
- Light in weight and easy to handle

- The pipes are easy to join

Disadvantage

- The pipes are affected by acidic or alkaline waters
- The useful life of pipes is short about 7 to 10 years.

5. Cement concrete pipes

Cement Concrete pipes may be either plain or reinforced and are best made by spinning process. They may be either pre-cast, or may be prepared at the site. The plain cement concrete pipes are used for heads up to 7 m while reinforced cement concrete pipes are normally used for heads 60 m.

Advantages

- They are more suitable to resist the external loads due to backfilling.
- They maintenance cost is low
- The inside surface of pipes can be made smooth, thus reducing the frictional losses.
- The problem of corrosion is not here.
- Pipes can be cast at site, and hence the transportation problems are reduced.
- Due to their heavy weight, the problem of floatation is not here when they are empty.

Disadvantages

- Un-reinforce d pipes are liable to tensile cracks, and they cannot withstand high pressure.
- The tendency of leakage is not ruled out as a result of its porosity and shrinkage cracks.
- It is very difficult to repair them.
- Pre-cast pipes are very heavy, and it is difficult to transport them.

6. Asbestos cement pipes

Asbestos cement pipes are manufactured from asbestos fiber and Portland cement combined under pressure to form a dense homogenous structure having strong bond between cement and the fiber. Such a pipe is claimed to be completely impervious to passage of water through its walls.

Advantages

- They have smooth internal surface, due to which the frictional losses are reduced.
- They are light and can be easily transported.
- They can be easily cut, fitted or jointed.
- Service connections can be easily taken, since they can be easily drilled and tapped
- They are anti-corrosive.

Disadvantages

- They are soft and brittle. they are very weak under impact loading due to moving traffic.
- They are cannot be laid in exposed places.
- They are not durable.
- They are costly.

7. P.V.C. Pipes

- Pipes are cheap
- The pipes are durable
- The pipes are flexible
- The pipes are free from corrosion
- The pipes are good electric insulators
- The pipes are light in weight and it can easy to mould any shape

Disadvantage

- The co-effcient of expansion for plastic is high
- It is difficult to obtain the plastic pipes of uniform composition
- The pipes are less resistance to heat
- Some types of plastic impart taste to the water.

8.Copper pipes

- Widely used for service connections

Advantages

- 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.

9. Lead pipes

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

3.3.1 STORAGE RESERVOIRS

Service Reservoirs or Distribution Reservoirs:

These are the storage reservoirs, which store the treated water for supplying water. Distribution reservoirs, also called service reservoirs, are the storage reservoirs, which store the treated water for supplying water during emergencies (such as during fires, repairs, etc.) and also to help in absorbing the hourly fluctuations in the normal water demand.

Functions of Distribution Reservoirs:

To absorb hourly variation demand.

To maintain constant pressure in the distribution mains

Location and Height of Distribution Reservoirs:

Distribution reservoir must be at a sufficient elevation to permit gravity flow at an adequate pressure.

Functions of Distribution Reservoirs

To equalize the variation in hourly demand of water by the consumers to a uniform rate of supply from the source either by gravity or pumping.

To maintain the desired minimum residual pressure in the distribution system.

To provide the required time for the disinfectant added in order to achieve effective disinfection and

To facilitate carrying out repairs either to the pumping or to pump-set without interruption to the supply of water. 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 purpose. • Ventilator for fresh air circulation.

Types of Distribution Reservoir

1. Surface reservoir
2. Elevated reservoir
3. Stand pipe

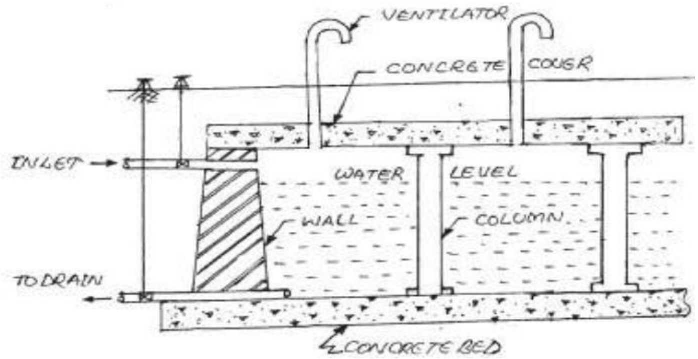
1. Surface Reservoirs

• Surface reservoirs are circular or rectangular tanks constructed at ground level or below ground level.

• Therefore they also called as ground reservoirs.

• They are generally constructed at high points in the city.

• In a gravitational type of distributional system. And pumping system used for treated water is filled the reservoirs.



2. Elevated Reservoirs

These are the elliptical overhead tanks erected at a certain suitable elevation above the G.L and supported on towers.

They are constructed in the areas combined gravity and pumping system for water distribution is adopted.

Water pumped into these elevated tanks from the filter units or from the service reservoirs and then supplied to consumers.

These tanks may be made of RCC, Steel or prestressed concrete.

TYPES OF TANKS

R.C.C TANKS: R.C.C tanks are very popular because

1) They have long life

2) Very little maintenance

3) Decent appearance

G.I. TANKS: G.I. tanks are generally in rectangular or square in shape. Now a days G.I. tanks are not preferring because

1) Life of the tank is short

2) Corrosion of metal

3) Maintenance cost may be more

TYPES OF TANKS

R.C.C TANKS: R.C.C tanks are very popular because

HDPE TANKS: Now a days HDPE tanks are very popular for storing less quantity of water and hence useful for residential purpose. The following are the advantages of HDPE tanks

1) Handling is easy because of light weight

2) Cheap in cost

3) Maintenance cost is low

4) Cleaning of tanks are easy

ESR...

ESR(Elevated Storage Reservoir) also referred to as Overhead Tanks are required at distribution areas which are not governed and controlled by the gravity system of distribution. These are rectangular, circular or elliptical in shape. If the topography of the town not suitable for under gravity, the elevated tank or reservoir are used.

Functions of Service Reservoirs:

Distribution reservoirs, also called service reservoirs, are the storage reservoirs, which store the treated water for supplying water during emergencies (such as during fires, repairs, etc.) and also to help in absorbing the hourly fluctuations in the normal water demand. Functions of Distribution Reservoirs

1. To absorb the hourly variations in demand.
2. To maintain constant pressure in the distribution mains.
3. Water stored can be supplied during emergencies.
4. Location and Height of Distribution Reservoirs
5. Should be located as close as possible to the centre of demand.
6. Water level in the reservoir must be at a sufficient elevation to permit gravity flow at an adequate pressure.

3.3.2 LAYOUTS OF DISTRIBUTION SYSTEM

The distribution pipes are generally laid below the road pavements, and as such their layouts generally follow the layouts of roads. There are, in general, four different types of pipe networks;any one of which either singly or in combinations, can be used for a particular place. They are:

1. Dead End System
2. Grid Iron System
3. Ring System
4. Radial System

1. Dead End System:

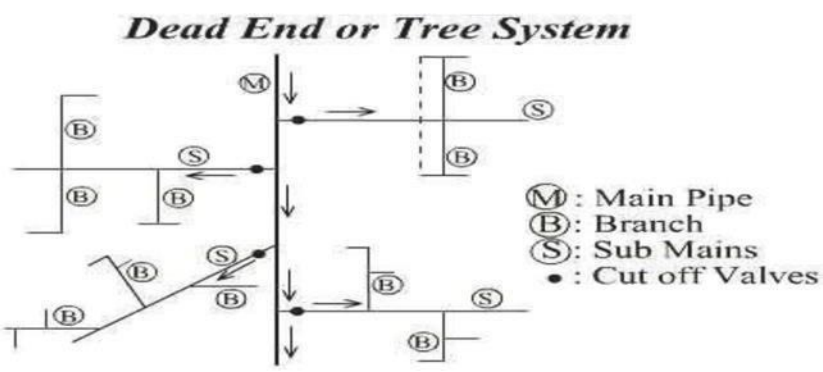
It is suitable for old towns and cities having no definite pattern of roads. It is also called tree system. It consists of one supply pipe, from which a number of sub-main pipes are originated.

-Each sub-mains, then divided in to several branch pipes called Laterals.

- From laterals service connections are given to consumers.

- The water supply mains have then be taken along the main roads, and

Branches taken off wherever needed, thus resulting in the formation of several dead ends.



Advantages

The distribution net-work can be easily solved.

- It is possible to easily and accurately calculate the discharge and pressures at different points in the system.

- Lesser number of cut-off valves is required in the system.

-Shorter pipe lengths are required,laying of pipes is easy.

- It is cheap and simple, can be extended and expanded easily.

-Relatively cheap.

-Determination of discharges and pressure easier due to less number of valves.

Disadvantages

-Water can reach a particular point through a single route ,if any damage or Repair in pipe will stop the supplying the area being fed by that pipe.

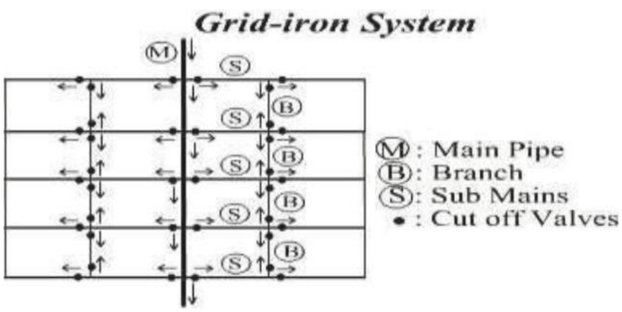
-There are numerous dead ends in this system, which prevent the free circulation of water

- Only limited supplies are available, so that it cannot be used in emergencies of fire fighting.

Due to many dead ends, stagnation of water occurs in pipes.

2.Grid Iron System:

It is also known as interlaced system or Reticulation system. The mains, sub-mains and branches are all inter-connected with each other. It is suitable for cities with rectangular layout, where the water mains and branches are laid in rectangles.



Advantages:

1. Water is kept in good circulation due to the absence of dead ends.

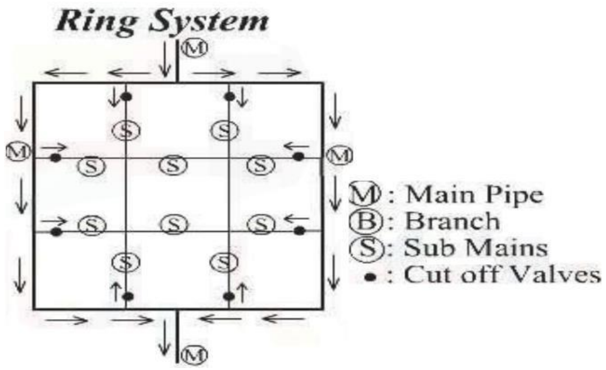
2. In the cases of a breakdown in some section, water is available from some other direction.

Disadvantages

1. Exact calculation of sizes of pipes is not possible due to provision of valves on all branches.

3. Ring system:

The supply main is laid all along the peripheral roads and sub mains branch out from the mains. Thus, this system also follows the grid iron system with the flow pattern similar in character to that of dead end system. So, determination of the size of pipes is easy.

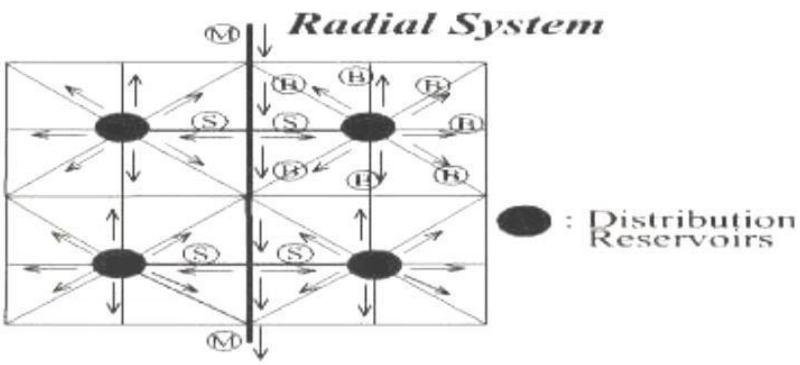


Advantages:

1. Water can be supplied to any point from at least two directions.

4. Radial system:

The area is divided into different zones. The water is pumped into the distribution reservoir kept in the middle of each zone and the supply pipes are laid radially ending towards the periphery.



Advantages:

1. It gives quick service.

2. Calculation of pipe sizes is easy.

3.3.3 HYDRAULICS OF PIPELINE

CONDUITS FOR WATER:

Conduit, channel or pipe for conveying water or other fluid or for carrying out certain other purposes, such as protecting electric cables.

Various types of conduits

Depending upon the conditions and characteristics of flow, the conduits may be divided into i) Gravity conduits ii) Pressure conduits

Gravity conduits are those in which the water flows under the mere action of gravity. In such a conduit, the gradient line will coincide with the water surface and will be parallel to the bed of the conduit. In such a there is no pressure term in Bernoulli's equation.

Gravity conduits can flow the water is all along at atmospheric pressure and be in the form of canals, flumes and aqueducts.

In pressure conduits, which are closed conduits and as such no air can enter into them, the water flows under pressure above the atmospheric pressure. The hydraulic gradient line for such a conduit can be obtained by joining the water surface elevations in the piezometers installed in the conduit at various places.

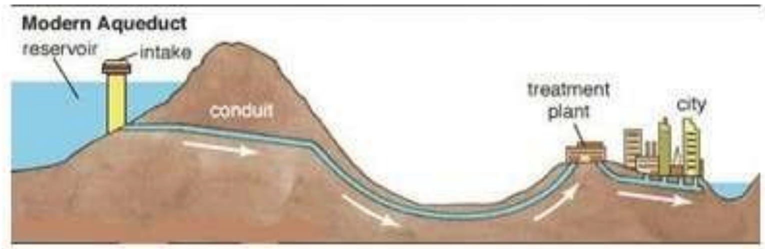
FLUMES:

A flume is man-made channel for water, in the form of an open inclined gravity chute whose walls are raised above the surrounding terrain. Used for the diversion of a stream

of water from a river for purposes of irrigation

AQUEDUCT:

Closed – rectangular or Circular or horse shoe section built of masonry or R.C.C.They are generally designed as ½ or 3/4th full. When designed as grade aqueducts, should not made to run full under pressure. Because of tension developed – open out joints of masonry work endangering structural stability – causing serious leakage.



Pressure Conduit:

Closed conduits – no air can enter into it. Water flows under pressure above the atmospheric pressure. Pressure pipes follow the natural available ground surface. Moves freely up and down hills or can dip beneath valleys or mountains. Pressure aqueducts / Pressure tunnels – closed pipes or closed aqueducts and tunnels. Circular in shape always – Hydraulic and structural reason. Due to Circular shape – pressure conduits are termed as Pressure pipe. Pressure pipe – drops beneath a valley, stream or some other depression – So called Sag / Depressed pipe / Inverted siphon.

Hydraulics of Flow in Pipes:

There are many basic principles that must be considered when preparing the hydraulic profile through the plant. The hydraulic profiles are prepared at peak and average design flows and at minimum initial flow. The hydraulic profile is generally prepared for all main paths of flow through the plant. The head loss through the treatment plant is the sum of head losses in the treatment units and the connecting piping and appurtenances.

The head losses through the treatment unit include the following:

- Head losses at the influent structure.
- Head losses at the effluent structure.
- Head losses through the unit.

The total loss through the connecting piping's, channels and appurtenances is the sum of following:

- Head loss due to entrance.
- Head loss due to exit.
- Head loss due to contraction and enlargement.
- Head loss due to friction.
- Head loss due to bends, fittings, gates, valves, and meters.

Hydraulic Design:

The design of water supply conduits depends on the resistance to flow, available pressure or head, and allowable velocities of flow. Allowable velocity is normally between 0.9 m/sec to 1.5 m/sec but velocity of 3 m/sec to 6 m/sec can be resisted by the commonly available pipe materials.

The Head loss caused by pipe friction can be found by using either of the following formulae:

<u>Darcy – Weisbach formula:</u>

$$H_L = \frac{f' L V^2}{d\, 2g}$$

H_L=Head Loss in metres

L = Length of pipe in metres

d = Diameter of the pipe in metres

V = Mean velocity of flow through the pipe in m/sec

g = Acceleration due to gravity

f ‘ = Dimensionless friction factor generally varying between 0.02 (for new smooth pipes) to (old rough pipes) and depends upon Reynold number.

<u>Manning’s formula:</u>

$$H_L = \frac{n^2 V^2 L}{R^{4/3}}$$

HL = Head loss in metres

n = Manning's rugosity coefficient

L = Length of pipes in metres

V = Mean velocity of flow through pipe in m/sec

R = Hydraulic mean depth of pipe (metres)

$$R = \frac{A}{P} = \frac{\frac{\pi d^2}{4}}{\pi d} = \frac{d}{4}$$

<u>Hazen-William's formula:</u>

$$V = 0.85 C_H . R^{0.63} . S^{0.54}$$

V = Mean velocity of flow through pipes in m/sec

R = Hydraulic mean depth of pipe (metres)

R =S = Slope of the energy line = HL/L

CH = Coefficient of hydraulic capacity Smoother the pipe – greater the CH value.

$$\frac{A}{P} = \frac{\frac{\pi d^2}{4}}{\pi d} = \frac{d}{4}$$

3.4 WATER DISTRIBUTION SYSTEM

Principles of design of water supply in Buildings:

- The design of pipe should be made so that there is no contact between the lines feeding to the cistern or any such other appliance with those feeding water for human consumption.
- Pipe network should be completely water tight and also remain undamaged either by traffic loads, vibrations or temperature and any strains of buildings.
- Pipe network in the premises should be optimum discharge of water is obtained consistent with economy. The system should be free from water hammer, corrosion and should also look aesthetic.
- Plumbing fixtures and appurtenances should be supplied with water in sufficient volume and at pressures adequate to function satisfactorily and without undue noise under all circumstances.
- The pipe network should be laid and fixed so that it shell be accessible at any time for attending to damages, leakages etc.
- The pipe network should be of adequate size to give the desired rate of flow
- The pipe network should be laid and fixed that it does not pass by the side of any sewage line or refuse drain nor does it pass through any field of foul ground where dirt or city have been deposited and manure dumps
- The pipe network should be divided into sections to facilitate repairs. These sections Should be separated by valves in order that a section can be isolated for repairs keepingthe rest of the distribution.
- The methods of joining pipe should be such as to avoid water loses.
- Whenever the pipes are bent it should be so made that these are not likely to materially diminish or alter cross section.
- The piping should be so laid that air locks do not occur and it should be possible toflush out the network from time to time.
- In the building if a provision is required to be made for storage of water on account of

1. In the interruption of supply

2. To maintain a reserve supply
3. To regulate discharge in the mains
4. To maintain a reserve for firefighting arrangements,

a tank for storage of water should be provided which should be watertight and also should be of sufficient thickness and capacity.

In the case of underground tanks, the contamination of stored water on account of above groundflow and due to seepage of underground water should be avoided.

Whenever underground tanks are required for firefighting purposes, the same should be approachable easily by fire tenders. The water which is required for firefighting is so provided that every day it gets renewal through an inflow of fresh water supply.

Lead piping should not be utilized anywhere in the domestic water supply system. Polythene and PVC pipes should not be installed near hot water pipes or near any source of heat.

The dead ends in the pipe lines should be avoided to the extent possible.

3.4.1 HOUSE SERVICE CONNECTION

Water supply to a house begins with connection of the service pipe with municipal water mains. The connection sequence comprises

a. Ferrule

b. Gooseneck

c. Service pipe

d. Stop cock

e. Water meter

To get water supply from municipalities connection consists of the following

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.

b. Goose Neck:

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

c. Service Pipe:

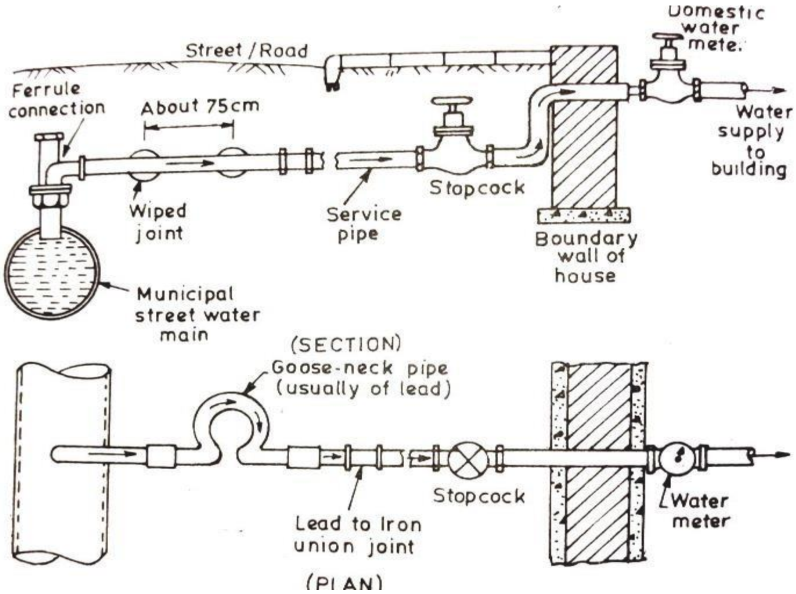
It is a galvanised iron pipe of size less than 50mm dia. It should be laid in under ground in a trench in which no sewage or drainage pipe is laid. The service pipe which supplies water to building through the municipal mains is connected to the main through goose neck and ferrule.

d. 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 removable cover and is fixed in the street close to the boundary wall in an accessible station.

e. Water Meter:

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



3.4.2 LAYING OF PIPELINE

The laying of pipeline should be done according to the following stages

1. Detailed map preparation.
2. Centre line marking.
3. Unloading.
4. Storing.
5. Cutting.
6. Trenches.
7. Laying
8. Back filling and tamping

1. Detailed map preparation.
   - Map showing all roads, cable lines, lanes etc., is prepared.
   - Pipe line with size and length is marked.
   - The position of existing pipe lines, curb lines, sewer lines will also be marked
2. Centre line marking.
   - Transformation from map to site.
   - Stakes driven at 30m interval on straight line .
   - stakes will be 7-15m on curves.
3. Unloading.
   - Up to 60kg – 2persons .
   - Above 60 kg – wagon/truck by holding it in rope and slides over planks set not steeper than 45°.
   - One pipe at a time.
   - It may use carriers or be dragged or rolled along hard surfaces
4. Storing.
   - To avoid damage.
   - It should be stored horizontaly .
   - It should be stored in layer

5. Cutting.
   - Mark with a chalk at the point o cut.
   - Cut with carpenter's saw or hack saw .
   - It must be a proper uniform cut.
6. Trenches.
   - It may be done either hand or machine.

   - It must be done with required gradient and depth.
   - When it is under a road way minimum cover of 1m is recommended.
   - Width at the base not less than 200mm on both side of the pipe.
   - Width may extend for joints .
7. LAYING
   - Pipes shall be lowered into the trenches by means of suitable pulley blocks , shear legs, chains, ropes .
   - in no case the pipe shall be rolled and
8. Dropped into the trench.
   - Spigot of one pipe is carefully centred into the socket of other pipe.
   - In some clay soil (black cotton soil) envelope of 10 cm minimum tamped sand shall be made around the pipe line.

9. Back filling and tamping

- Back filling must be done carefully to avoid damages in pipe form fallingof boulders, lifting of pipes from sudden floods.
- Soil under and around the pipe line is tamped to give continuous supportsto the pipe.
- It may be done by tamping rod or water consolidation.
- The initial backfill done for 10 cm thick.

TESTING OF PIPE:

Step 1: From section to section. One section at a time.

Step 2: Downstream valve is closed, upstream valve is opened to fill the water.

Air valves must be properly operated during filling.

Step 3: Both the sluice gates are closed.

Step 4: Pressure gauge is fitted along the length of the pipes at holes which is leftfor this purpose.

Step 5:Section is connected to the delivery side of the pump through a smallBy- pass valve to develop pressure in the section.

Step 6: By-pass valve is closed.

Step 7: It kept under pressure for 24 hours and inspected for possible defects ,leakages and joints.

Step 8: Pipe line is disinfected . Add chlorine 50mg/l for 12 hours and the pipe isemptied and flushed with treated water.

3.4.3 DISTRIBUTION SYSTEM

Depending upon the level of source, topography of the area and other local conditions the water may be forced into distribution system by following ways

1. Gravity system
2. Pumping system
3. Combined gravity and pumping system

Gravity system..

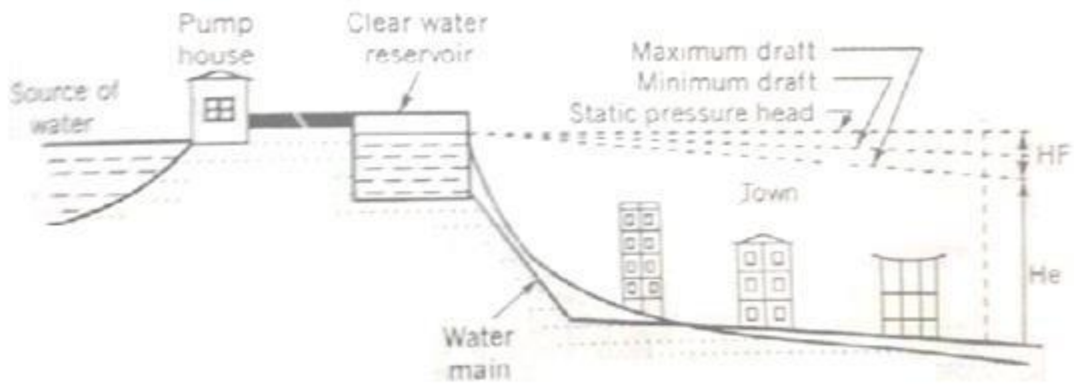
a) Suitable when source of supply is at sufficient height.

b) Most reliable and economical distribution system.

c) The water head available at the consumer is just minimum required.

d) The remaining head is consumed in the frictional and other losses.

e) Water flows in mains due to gravitational pull, no pumping is required.



Pumping system…

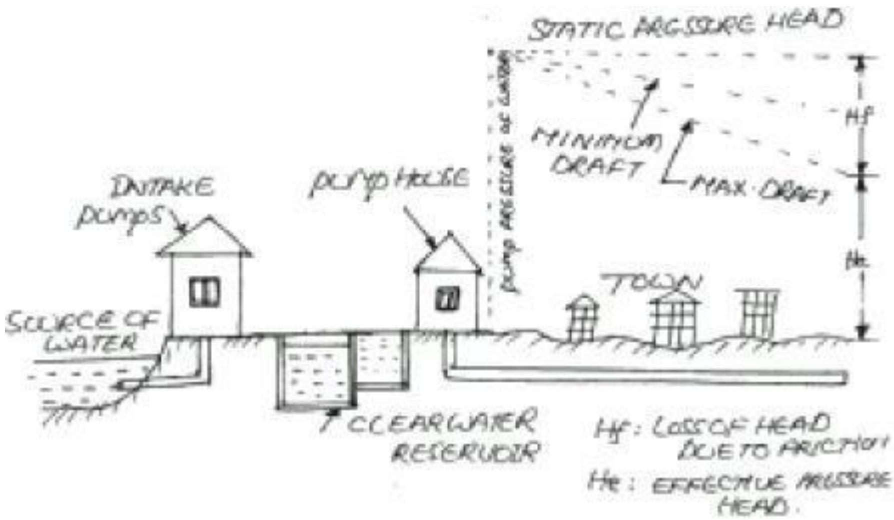
a) Treated water is directly pumped in to the distribution main without storing.

b)Also called pumping without storage system.

c)High lifts pumps are required.

d)If power supply fails, complete stoppage of water supply.

e)This method is not generally used.



Combined gravity and pumping system..

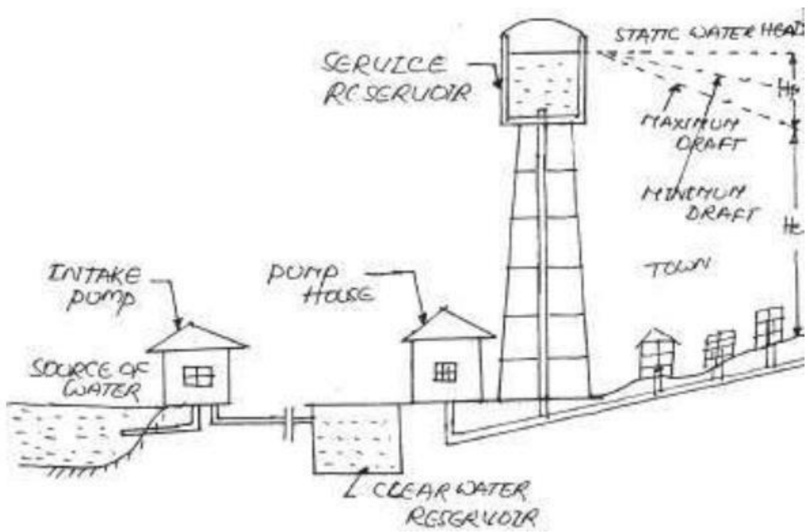
a) Most common system.

b) Treated water is pumped and stored in an elevated distribution reservoir.

c) Then supplies to consumer by action of gravity.

d) The excess water during low demand periods get stored in reservoir and get suppliedduring high demand period.

e) Economical, efficient and reliable system.



Requirements of good Distribution System:

Water Distribution Systems

The purpose of distribution system is to deliver water to consumer with appropriate quality, quantity and pressure. Distribution system is used to describe collectively the facilities used to supply water from its source to the point of usage.

Requirements of Good Distribution System

1. Water quality should not get deteriorated in the distribution pipes.

2. It should be capable of supplying water at all the intended places with sufficientpressure head.

3. It should be capable of supplying the requisite amount of water during fire fighting.

4. The layout should be such that no consumer would be without water supply, duringthe repair of any section of the system.

5. All the distribution pipes should be preferably laid one metre away or above thesewer lines.

6. It should be fairly water-tight as to keep losses due to leakage to the minimum.

4.1 TYPES OF SEWERAGE SYSTEMS

1) Separate system of sewage
2) Combined system of sewage
3) Partially combined or partially separate system

SEPARATE SYSTEM OF SEWERAGE

In this system two sets of sewers are laid. The sanitary sewage is carried through sanitary sewers while the storm sewage is carried through storm sewers. The sewage is carried to the treatment plant and storm water is disposed of to the river.

Advantages:

1) Size of the sewers is small
2) Sewage load on treatment unit is less
3) Rivers are not polluted
4) Storm water can be discharged to rivers without treatment.

Disadvantage:

1) Sewerage being small, difficulty in cleaning them
2) Frequent choking problem will be their.
3) System proves costly as it involves two sets of sewers
4) The use of storm sewer is only partial because in dry season the will be converted into dumping places and may get clogged.

COMBINED SYSTEM OF SEWAGE

When only one set of sewers are used to carry both sanitary sewage and surface water.This system is called combined system.

Sewage and storm water both are carried to the treatment plant through combined sewers.

Advantages:

1) Size of the sewers being large, chocking problems are less and easy to clean.
2) It proves economical as 1 set of sewers are laid.
3) Because of dilution of sanitary sewage with storm water nuisance potential is reduced

Disadvantages:

1) Size of the sewers being large, difficulty in handling and transportation.
2) Load on treatment plant is unnecessarily increased

3) It is uneconomical if pumping is needed because of large amount of combined flow.

4) Unnecessarily storm water is polluted

PARTIALLY COMINED OR PARTIALLY SEPARATE SYSTEM

A portion of storm water during rain is allowed to enter sanitary sewer to treatment plants while the remaining storm water is carried through open drains to the point of disposal.

Advantages:

1) The sizes of sewers are not very large as some portion of storm water is carried through open drains.

2) Combines the advantages of both the previous systems.

3) Silting problem is completely eliminated

Disadvantages:

1) During dry weather, the velocity of flow may be low.

2) The storm water is unnecessary put load on to the treatment plants to extend.

Suitable conditions for separate sewerage systems:

A separate system would be suitable for use under the following situations:

1. Where rainfall is uneven.
2. Where sanitary sewage is to be pumped.
3. The drainage area is steep, allowing to runoff quickly.
4. Sewers are to be constructed in rocky strata.
5. The large combined sewers would be more expensive.

Suitable conditions for combined system:

1. Rainfall in even throughout the year.
2. Both the sanitary sewage and the storm water have to be pumped.
3. The area to be severed is heavily built up and space for laying two sets of pipes is not enough.
4. Effective or quicker flows have to be provided.

After studying the advantages and disadvantages of both the systems, present day construction of sewers is largely confined to the separate systems except in those cities where combined system already exists. In places where rainfall is confined to one season of the year, like India and even in temperate regions, separate system is most suitable.

Sl. no.	Separate system	Combined system
1.	The quantity of sewage to be treated is less, because no treatment of storm water is done.	As the treatments of both are done, the treatment is costly.
2.	In the cities of more rainfall this system is more suitable.	In the cities of less rainfall this system is suitable.
3.	As two sets of sewer lines are to laid, this system is cheaper because sewage is carried in underground sewers and storm	Overall construction cost is higher than separate system.
4.	In narrow streets, it is difficult to use this system.	It is more suitable in narrow streets.
5.	Less degree of sanitation is achieved in this system, as storm water is disposed without any treatment.	High degree of sanitation is achieved in this system.

Methods of domestic waste water disposal:

After the waste water is treated it is disposed in the nature in the following two principal methods

a. Disposal by Dilution where large receiving water bodies area available

b. Land disposal where sufficient land is available

The choice of method of disposal depends on many factors and is discussed later. Sanitary engineering starts at the point where water supply engineering ends. It can be classified as

- Collection works
- Treatment works
- Disposal works

- The collection consists of collecting tall types of waste products of town. Refuse is collected separately. The collection works should be such that waste matters can be transported quickly and steadily to the treatment works. The system employed shouldbe self-cleaning and economical.

- Treatment is required to treat the sewage before disposal so that it may not pollute the atmosphere & the water body in which it will be disposed of. The type of treatment processes depends on the nature of the waste water characteristics and hygiene, aesthetics and economical aspects.

- The treated water is disposed of in various ways by irrigating fields or discharging in to natural water courses.

4.1.1 SEWAGE TYPES

1) Conservancy System
2) Water Carriage System

CONSERVENCY SYSTEM:

Sometimes the system is also called as dry system. This is out of date system but is prevailing in small towns and villages. Various types of refuse and storm water are collected conveyed and disposed of separately. Garbage is collected in dustbins placed along the roads from where it is conveyed by trucks ones or twice a day to the point of disposal. all the non-combustible portion of garbage such as sand dust clay etc are used for filling the low level areas to reclaim land for the future development of the town. The combustible portion of the garbage is burnt. The decaying matters are dried and disposed of by burning or the manufacture of manure.

Human excreta are collected separately in conservancy latrines. The liquid and semi liquid wastes are collected separately after removal of night soil it is taken outside the town in trucks and buried in trenches. After 2-3 years the buried night soil is converted into excellent manure. In conservancy system sullage and storm water are carried separately in closed drains to the point of disposal where they are allowed to mix with river water without treatment.

WATER CARRIAGE SYSTEM

With development and advancement of the cities urgent need was felt to replace conservancy system with some more improved type of system in which human agency should not be used for the collection and conveyance of sewage. After large number of experiments it was found that the water is the only cheapest substance which can be easily used for the collection and conveyance of sewage. As in this system water is the main substance therefore it is called as water carriage system.

In this system the excremental matter is mixed up in large quantity of water their taken out from the city through properly designed sewerage systems, where they are disposed of after necessary treatment in a satisfactory manner.

The sewages so formed in water carriage system consist of 99.9% of water and .1% solids. All these solids remain in suspension and do not changes the specific gravity of water therefore all the hydraulic formulae can be directly used in the design of sewerage system and treatment plants.

Difference between Conservancy system and Water carriage system:

CONSERVENCY SYSTEM	WATER CARRIAGE SYSTEM
Very cheap in initial cost.	It involves high initial cost.
Due to foul smells from the latrines, they are to be constructed away from living room so building cannot be constructed as compact units.	As there are no foul smell latrines remain clean and neat and hence are constructed with rooms, therefore buildings may be compact.
The aesthetic appearance of the city cannot be improved	Good aesthetic appearance of city can be obtained.
For burial of excremental matter large area is required.	Less area is required as compared to conservancy system.
Excreta is not removed immediately hence its decomposition starts before removal,	Excreta are removed immediately with water, no problem of foul smell or hygienic trouble.
This system is fully depended on human agency .In case of strike by the sweepers; there is danger of insanitary conditions in	As no human agency is involved in this system ,there is no such problem as in case of conservancy system

4.2 COLLECTION OF SEWERAGE SYSTEM

One of the fundamental principles of sanitation of the community is to remove all decomposable matter, solid waste, liquid or gaseous away from the premises of dwellings as fast as possible after it is produced, to a safe place, without causing any nuisance and dispose it in a suitable manner so as to make it permanently harmless.

Sanitation though motivated primarily for meeting the ends of preventive health has come to be recognized as a way of life. In this context, development of the sanitation infrastructure of any country could possibly serve as a sensitive index of its level of prosperity. It is needless to emphasize that for attaining the goals of good sanitation, sewerage system is very essential.

Sources of Sewage:

Sanitary sewage is produced from the following sources:
When the water is supplied by water works authorities or provided from private sources, it is used for various purposes like bathing, utensil cleaning, for flushing water closets and urinals or washing clothes or any other domestic use. The spent water for all the above needs forms the sewage.

1. Industries use the water for manufacturing various products and thus develop the sewage.
2. Water supplied to schools, cinemas, hotels, railway stations, etc., when gets used develops sewage.
3. Ground water infiltration into sewers through loose joints.
4. Unauthorized entrance of rain water in sewer lines.

Nature of Sewage:

Sewage is a dilute mixture of the various types of wastes from the residential, public and industrial places. The characteristics and composition i.e. the nature of sewage mainly depends on this source. Sewage contains organic and inorganic matters which may be dissolved, suspension and colloidal state. Sewage also contains various types of bacteria, Virus, protozoa, etc. sewage may also contain toxic or other similar materials which might have got entry from industrial discharges. Before the design of any sewage treatment plant the knowledge of the nature of sewage is essential.

4.1.1 DEFINITIONS

Definitions of some common terms used in the sanitary engineering:

REFUSE:

This is the most general term to indicate the wastes which include all the rejects left as worthless, sewage, sullage – all these terms are included in this term.

GARBAGE:

It is a dry refuse which includes, waste papers, sweepings from streets and markets, vegetable peelings etc. The quantity of garbage per head per day amounts to be about .14 to .24 kg for Indian conditions. Garbage contains large amount of organic and putrefying matter and therefore should be removed as quickly as possible.

RUBBISH:

It consists of sundry solid wastes from the residencies, offices and other buildings. Broken furniture, paper, rags etc are included in this term. It is generally dry and combustible.

SULLAGE:

It is the discharge from the bath rooms, kitchens, wash basins etc., it does not include discharge from the lavatories, hospitals, operation theaters, slaughter houses which has a high organic matter.

SEWAGE:

It is a dilute mixture of the wastes of various types from the residential, public and industrial places. It includes sullage water and foul discharge from the water closets, urinals, hospitals, stables, etc.

STORM WATER:

It is the surface runoff obtained during and after the rainfall which enters sewers through inlet. Storm water is not foul as sewage and hence it can be carried in the open drains and can be disposed off in the natural rivers without any difficulty.

SANITARY SEWAGE:

It is the sewage obtained from the residential buildings & industrial effluents establishments‘. Being extremely foul it should be carried through underground conduits.

DOMESTIC SEWAGE:

It is the sewage obtained from the lavatory basins, urinals &water closets of houses, offices & institutions. It is highly foul on account of night soil and urine contained in it. Night soil starts putrefying & gives offensive smell. It may contain large amount of bacteria due to the excremental wastes of patients. This sewage requires great handling &disposal.

INDUSTRIAL SEWAGE:

It consists of spent water from industries and commercial areas. The degree of foulness depends on the nature of the industry concerned and processes involved.

SEWERS:

Ewers are underground pipes which carry the sewage to a point of disposal.

SEWERAGE:

The entire system of collecting, carrying &disposal of sewage through sewers is known as sewerage.

DRY WEATHER FLOW (DWF):

Domestic sewage and industrial sewage collectively, is called as DWF. It does not contain storm water. It indicates the normal flow during dry season.

BACTERIA:

These are the microscopic organisms. The following are the groups of bacteria:

-Aerobic bacteria: they require oxygen &light for their survival.

-Anaerobic bacteria: they do not require free oxygen and light for survival.

- Facultative bacteria: they can exist in the presence or absence of oxygen. They grow more in absence of air.

Invert:

It is the lowest point of the interior of the sewer at any c/s.

SLUDGE:

It is the organic matter deposited in the sedimentation tank during treatment.

4.3 SEWER MATERIALS

Sewer is a pipe or conduit carrying sewage. Sewers are usually not flow full (Gravity Flow). The full flowing sewers are called force main as the flow is under pressure.

Following are types of sewer according to material

1. Asbestos Cement (AC) Sewer
2. Brick Sewer
3. Cement Sewer
4. Cast iron (CI) Sewer
5. Steel Sewers
6. Plastic Sewers

1. Asbestos Cement (AC) Sewer

Types of sewer like Asbestos Cement (AC) Sewers are manufactured from a mixture of cement and asbestos fiber. Asbestos Cement (AC) Sewers are suitable for carrying domestic sanitary sewage.

Asbestos cement sewer is best as vertical pipe for carrying sullage from upper floors of multistory buildings (in two pipe system of plumbing).

Advantages of Asbestos Cement (AC) Sewer

1. Smooth
2. Light in weight
3. Can easily be cut, fitted and drilled
4. Durable against soil corrosion

Disadvantages of Asbestos Cement (AC) Sewer

1. Brittle cannot withstand heavy loads
2. They are easily broken in handling and transport.

2. Brick Sewers

These types of sewer (Brick Sewers) are made at site and used for construction large size sewer. Brick Sewers are very useful for construction of storm sewer or combined sewer. Nowadays brick sewers are replaced by concrete sewer. Brick sewers my get deformed and leakage may take place. A lot of labour work is required.

Note: To avoid leakage the brick sewer should be plastered.

3. Cement Concrete

i. PCC - for dia upto 60 cm

Suitable for small storm drains. Not durable.

ii. RCC - for dia > 60 cm

They may be cast in situ or precast, resistant to heavy loads, corrosion and high pressure. These are very heavy and difficult to transport.

4. Cast Iron (CI) Sewers

These types of sewer are High strength and durability water tight. Cast Iron sewers can withstand high internal pressure and can bear external load. Cast Iron sewers are suitable for the following conditions.

When the sewage is conveyed under high pressure.

When the sewer line is subject to heavy external load e.g. under railway line

When there is considerable difference in temperature.

5. Steel Sewers

These types of sewer (steel sewers) are Impervious, light, resistant to high pressure, flexible, suitable when;

The sewage is carried under pressure

The sewage has to be carried across a river under waterThe

sewer has to cross under a railway track.

6. Plastic sewers

Nowadays PVC sewers are used for carrying sewage. Plastic sewers are resistant to corrosion. Such types of sewer are light in weight, smooth and can be bent easily. But these types of sewer (Plastic sewers) are having high co-efficient of thermal expansion and cannot be used in very hot areas.

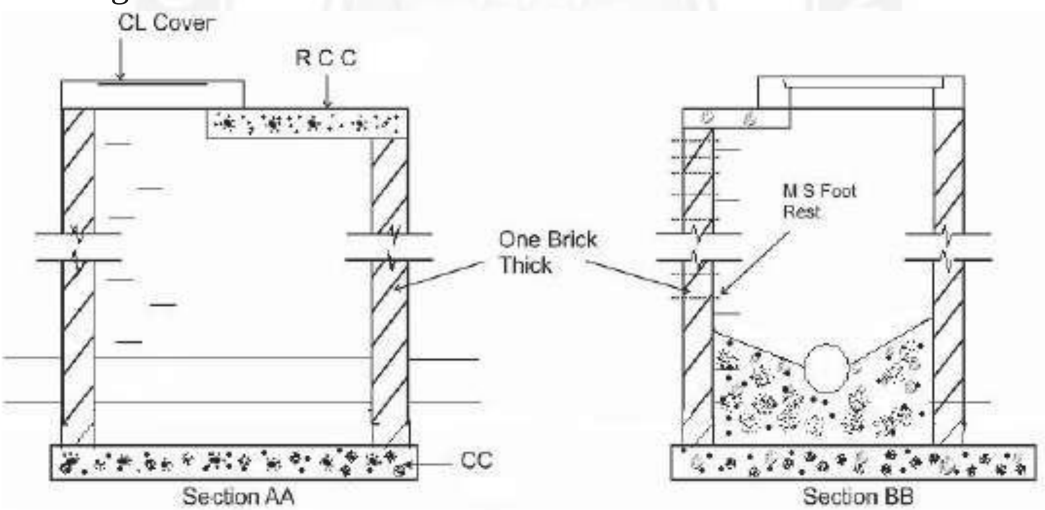
4.3.1 SEWER APPURTENANCES

The structures, which are constructed at suitable intervals along the sewerage system to help its efficient operation and maintenance, are called as sewer appurtenances. These include:

(1) Manholes, (2) Drop manholes, (3) Lamp holes,
(4) Clean-outs, (5) Street inlets (6) Catch basins,
(7)Inverted siphon,

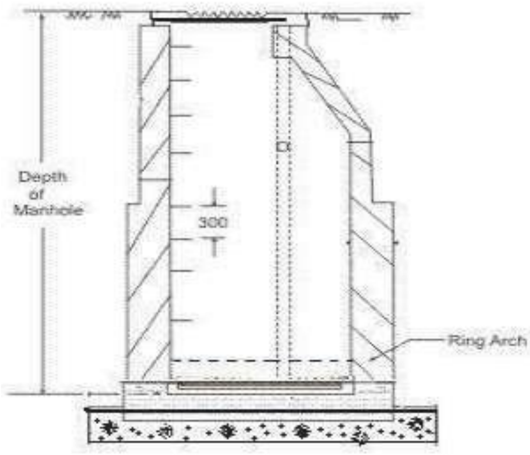
Manholes

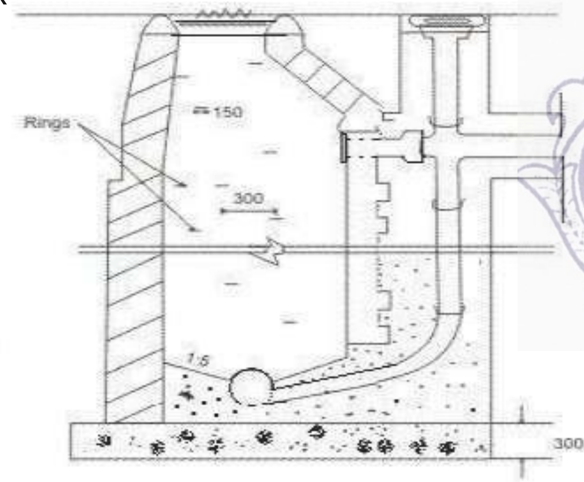
The manhole is masonry or R.C.C. chamber constructed at suitable intervals along the sewer lines, for providing access into them. Thus, the manhole helps in inspection, cleaning and maintenance of sewer. These are provided at every bend, junction, change of gradient or change of diameter of the sewer. The sewer line between the two manholes is laid straight with even gradient. For straight sewer line manholes are provided at regular interval depending upon the diameter of the sewer. The minimum width of the manhole should not be less than internal diameter of the sewer pipes plus 150 mm benching on both the sides.



Drop Manholes

When a sewer connects with another sewer, where the difference in level between invert level of branch sewer and water line in the main sewer at maximum discharge is greater than 0.6 m, a manhole may be built either with vertical or nearly vertical drop pipe from higher sewer to the lower one. The drop manhole is also required in the same sewer line in sloping ground, when drop more than 0.6 m is required to control the gradient and to satisfy the maximum velocity i.e., non-scouring velocity.



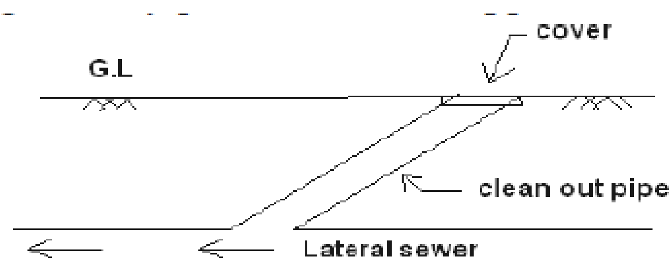


Lamp hole

It is an opening or hole constructed in a sewer for purpose of lowering a lamp inside it. It consists of stoneware or concrete pipe, which is connected to sewer line through a T-junction as shown in the. The pipe is covered with concrete to make it stable. Manhole cover of sufficient strength is provided at ground level to take the load of traffic. An electric lamp is inserted in the lamp hole and the light of lamp is observed from manholes. If the sewer length is unobstructed, the light of lamp will be seen. It is constructed when construction of manhole is difficult. In present practice as far as possible the use of lamp hole is avoided. This lamp hole can also be used for flushing the sewers. If the top cover is perforated it will also help in ventilating the sewer, such lamp hole is known as fresh air inlet.

Clean out

It is a pipe which is connected to the underground sewer. The other end of the clean-out pipe is brought up to ground level and a cover is placed at ground level (Figure 8.8). A clean-out is generally provided at the upper end of lateral sewers in place of manholes.



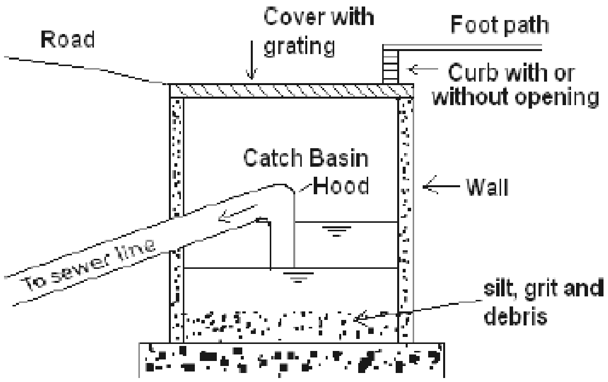
During blockage of pipe, the cover is taken out and water is forced through the clean-out pipe to lateral sewers to remove obstacles in the sewer line. For large obstacles, flexible rod may be inserted through the clean-out pipe and moved forward and backward to remove such obstacle.

Storm water inlets

Storm water inlets are provided to admit the surface runoff to the sewers. These are Classified in three major groups viz. curb inlets, gutter inlets, and combined inlets. They are provided either depressed or flush with respect to the elevation of the pavement surface. The structure of the inlet is constructed with brickwork with cast iron grating at the opening confirming to IS 5961. Where the traffic load is not expected, fabricated steel grating can be used. The clear opening shall not be more than 25 mm. The connecting pipe from the street inlet to the sewer should be minimum of 200 mm diameter and laid with sufficient slope. A maximum spacing of 30 m is recommended between the inlets, which depends upon the road surface, size and type of inlet and rainfall.

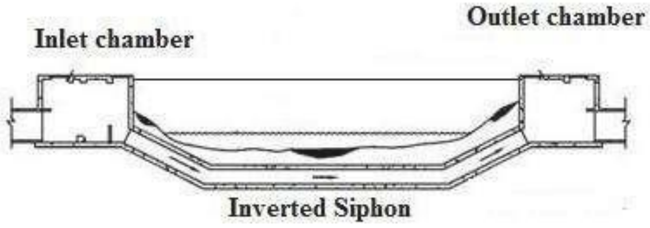
Catch basins

Catch basins are provided to stop the entry of heavy debris present in the storm water into the sewers. However, their use is discouraged because of the nuisance due to mosquito breeding apart from posing substantial maintenance problems. At the bottom of the basin space is provided for the accumulation of impurities. Perforated cover is provided at the top of the basin to admit rain water into the basin. A hood is provided to prevent escape of sewer gas.



Inverted Siphon

An inverted siphon or depressed sewer is a sewer that runs full under gravity flow at a pressure above atmosphere in the sewer. Inverted siphons are used to pass under obstacles such as buried pipes, subways, etc. This terminology 'siphon' is misnomer as there is no siphon action in the depressed sewer. As the inverted siphon requires considerable attention for maintenance, it should be used only where other means of passing an obstacle inline of the sewer are impracticable.



4.4 PLUMBING SYSTEMS IN BUILDING (SEWAGE AND DRAINAGE)

Following are the four principle systems adopted in plumbing work in building

1. Two pipe system.
2. One pipe system.
3. Single stack system
4. Partially ventilated single stack system.

1) Two pipe system:

1. This is the best and most improved type of system of plumbing.

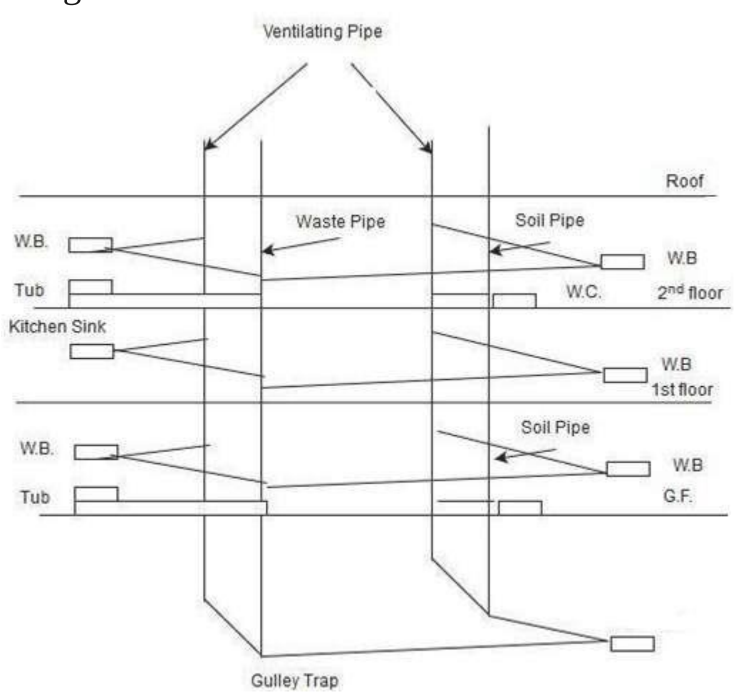
2. In this system, two sets of vertical pipes are laid, i.e. one for draining night soil and other for draining sullage.

3. The pipe of the first set carrying night soil are called soil pipes. and the pipes of the second set carrying sullage from baths etc are called sullage pipe or waste pipe

4. The soil fixtures, such as latrines and urinals are thus all connected through branch pipes to the vertical pipe.

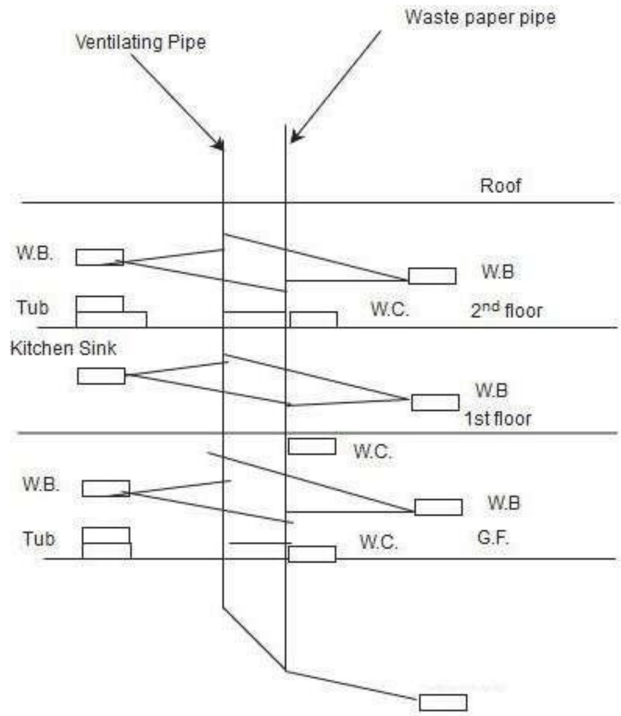
5. Where the sludge fixtures such as baths, sinks, wash-basins, etc are all connected through branch pipes to the vertical waste pipe.

6. The soil pipe as well as the waste pipe are separately ventilated by providing separate vent pipe as shown in figure



2) One pipe system:

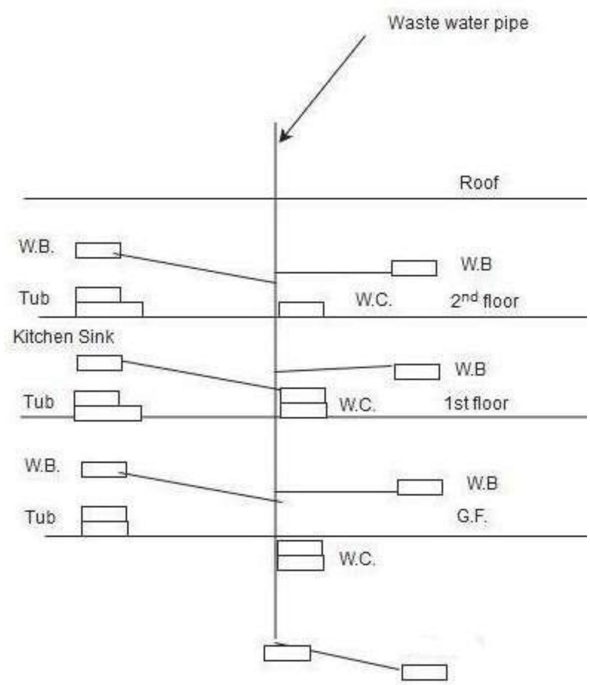
In this system, instead of using two separate pipes (for carrying sullage and night soil, as it done in the above described two pipe system), only main vertical pipe is provided which collects the night soil as well as the sullage water from their respective fixtures through the branch pipes. This main pipe is ventilated in itself by providing cowl at its top and in addition to this, a separate vent pipe is also provided, as shown in the figure.



3) Single Stack System:

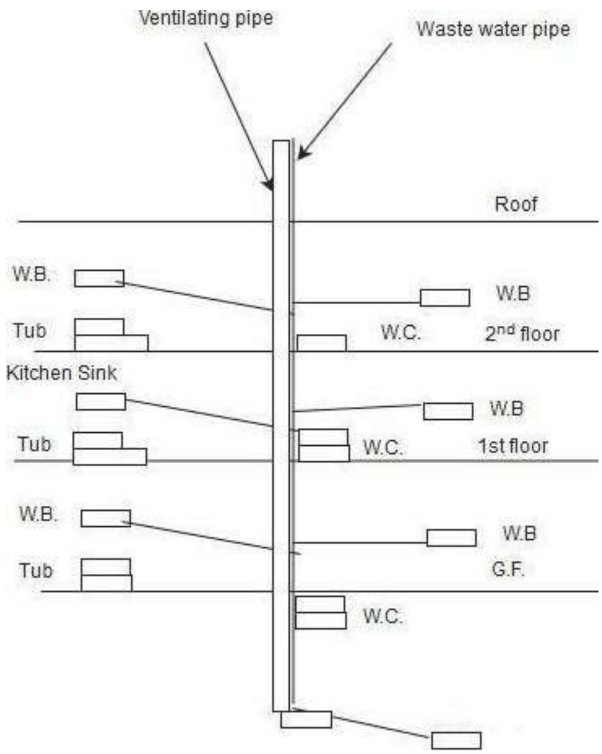
This system is a single pipe system without providing any separate ventilation pipe.

It uses only one pipe which carries the sewage as well as sullage, and is not provided with any separate vent pipe, except that it itself is extended up to about 2m higher than the roof level and provided with a cowl for removal of foul gases as shown in fig.



4) Partially ventilated single stack:

This is an improved form of single stack system in the sense that in this system, the traps of water closets are separately ventilated by a separate vent pipe called relief vent pipe. This system uses two pipes as in single pipe system but the cost of branches is considerably reduced compared to single pipe system.



4.4.1 STORM WATER

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

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

Estimate of Sanitary Sewage:

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

The sewage may be classified under two heads:

1. The sanitary sewage, and
2. Storm water

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

Quantity of Sewage:

It is usual to assume that the rate of sewage flow, including a moderate allowance for infiltration equals to average rate of water consumption which is 135 litre/ head /day according to Indian Standards. It varies widely depending on size of the town etc. this quantity is known as Dry Weather Flow (D.W.F). It is the quantity of water that flows through sewer in dry weather when no storm water is in the sewer.

Rate of flow varies throughout 24 hours and is usually the greatest in the fore-noon and very small from midnight to early morning. For determining the size of sewer, the maximum flow should be taken as three times the D.W.F.

Design Discharge of Sanitary Sewage

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

Factors affecting the quantity of sewage flow: -

The quantity of sanitary sewage is mainly affected by the following factors:

1. Population
2. Type of area
3. Rate of water supply
4. Infiltration and exfiltration

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

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

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

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

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

Rate of water

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

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

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

Infiltration causes increase to the ―legitimate‖ flows in urban sewerage systems. Infiltration represents a slow response process resulting in increased flows mainly due to seasonally-elevated groundwater entering the drainage system, and primarily occurring through defects in the pipe network.

Exfiltration represents losses from the sewer pipe, resulting in reduced conveyance flow rate is due to leaks from defects in the sewer pipe walls as well as overflow discharge into manholes, chambers and connecting surface water pipes. The physical defects are due to a combination of factors including poor construction and pipe joint fittings, root penetration, illicit connections, biochemical corrosion, soil conditions and traffic loadings as well as aggressive groundwater.

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

Quantity of storm water:

When rain falls over the ground surface, a part of it percolates into the ground, a part is evaporated in the atmosphere and the remaining part overflows as storm water. This quantity of storm water is very large as compared with sanitary sewage.

Factors affecting storm water:

The following are factors which affect the quantity of storm water:

1. Rainfall intensity and duration.
2. Area of the catchment.
3. Slope and shape of the catchment area.
4. Nature of the soil and the degree of porosity.
5. Initial state of the catchment.

If rainfall intensity and duration is more, large will be the quantity of storm water available. If the rainfall takes place very slowly even though it continues for the whole day, the quantity of storm water available will be less.

Harder surface yield more runoff than soft, rough surfaces. Greater the catchment area greater will be the amount of storm water. Fan shaped and steep areas contribute more quantity of storm water. In addition to the above it also depends on the temperature, humidity,wind etc.

Estimate of quantity of storm water: -

Generally, there are two methods by which the quantity of storm water is calculated:

1. Rational method
2. Empirical formulae method

In both the above methods, the quantity of storm water is a function of the area, the intensity of rainfall and the co-efficient of runoff.

Rational method:

Runoff from an area can be determined by the Rational Method.The method gives a reasonable estimate up to a maximum area of 50 ha (0.5 Km2).

The minimum duration to be used for computation of rainfall intensity is 10 minutes. If the time of concentration computed for the drainage area is less than 10 minutes, then 10 minutes should be adopted for rainfall intensity computations.

This method is mostly used in determining the quantity of storm water. The storm water quantity is determined by the rational formula:

$$Q = \frac{C.i.A}{360}$$

5.1 SEWAGE TREATMENT METHODS

PRIMARY SEDIMENTATION TANK

After grit removal in grit chamber, the wastewater containing mainly lightweight organic matter is settled in the primary sedimentation tank (PST). Due to involvement of many unknown parameters under settling of light weight, sticky, and non regular shaped particles, the classical laws of sedimentation as applicable in grit removal are not valid and this settling is called as flocculant settling. The primary sedimentation tank generally removes 30 to 40% of the total BOD and 50 to 70% of suspended solids from the raw sewage.

The flow through velocity of 1 cm/sec at average flow is used for design with detention period in the range of 90 to 150 minutes. This horizontal velocity will be generally effective for removal of organic

suspended solids of size above 0.1 mm. Effluent weirs are provided at the effluent end of the rectangular tanks, and around the periphery in the circular tanks. Weir loading less than 185m3/m.d is used for designing effluent weir length (125 to 500 m3/m.d). Where primary treatment follows secondary treatment, higher weir loading rates can be used. The sludge collection hopper is provided near the centre in circular tank and near the influent end in rectangular tanks. A baffle is provided ahead of the effluent weir for removal of floating matter. This scum formed on the surface is periodically removed from the tank mechanically or manually.

The efficiency of the sedimentation tank, with respect to suspended solids and BOD removal, is affected by the following:

- Eddy currents formed by the inertia of incoming fluid,
- Wind induced turbulence created at the water surface of the uncovered tanks,
- Thermal convection currents,
- Cold or warm water causing the formation of density currents that moves along the bottom of the basin, and Thermal stratification in hot climates.

Because of the above reasons the removal efficiency of the tank and detention time has correlation $R = t/(a+b.t)$, where ‘a’ and ‘b’ are empirical constants, ‘R’ is expected removal efficiency, and ‘t’ is nominal detention time.

To account for the non optimum conditions encountered in the field, due to continuously wastewater coming in and going out of the sedimentation tank, due to ripples formed on the surface of the water because of wind action, etc., the settling velocity (overflow rate) obtained from the column studies are often multiplied by a factor of 0.65 to 0.85, and the detention time is multiplied by a factor of 1.25 to 1.50. This will give adequate treatment efficiency in the field conditions as obtained under laboratory test.

Recommendation for Design of Primary Sedimentation Tank

Primary sedimentation tanks can be circular or rectangular tanks designed using average dry weather flow and checked for peak flow condition. The numbers of tanks are determined by limitation of tank size. Two tanks in parallel are normally used to facilitate maintenance of any tank. The diameter of circular tank may range from 3 to 60 m (up to 45 m typical) and it is governed by structural requirements of the trusses which supports scrapper in case of mechanically cleaned tank. Rectangular tank with length 90 m are in use, but usually length more than 40 m is not preferred. Width of the tank is governed by the size of the scrappers available for mechanically cleaned tank. The depth of mechanically cleaned tank should be as shallow as possible, with minimum 2.15 m. The average depth of the tank used in practice is about 3.5 m. In addition, 0.25 m for sludge zone and 0.3 to 0.5 m free board is provided. The floor of the tank is provided with slope 6 to 16 % (8 to 12 % typical) for circular tank and 2 to 8% for rectangular tanks. The scrappers are attached to rotating arms in case of circular tanks and to endless chain in case of rectangular tanks. These scrappers collect the solids in a central sump and the solids are withdrawn regularly in circular tanks. In rectangular tanks, the solids are collected in the sludge hoppers at the influent end, and are withdrawn at fixed time intervals.

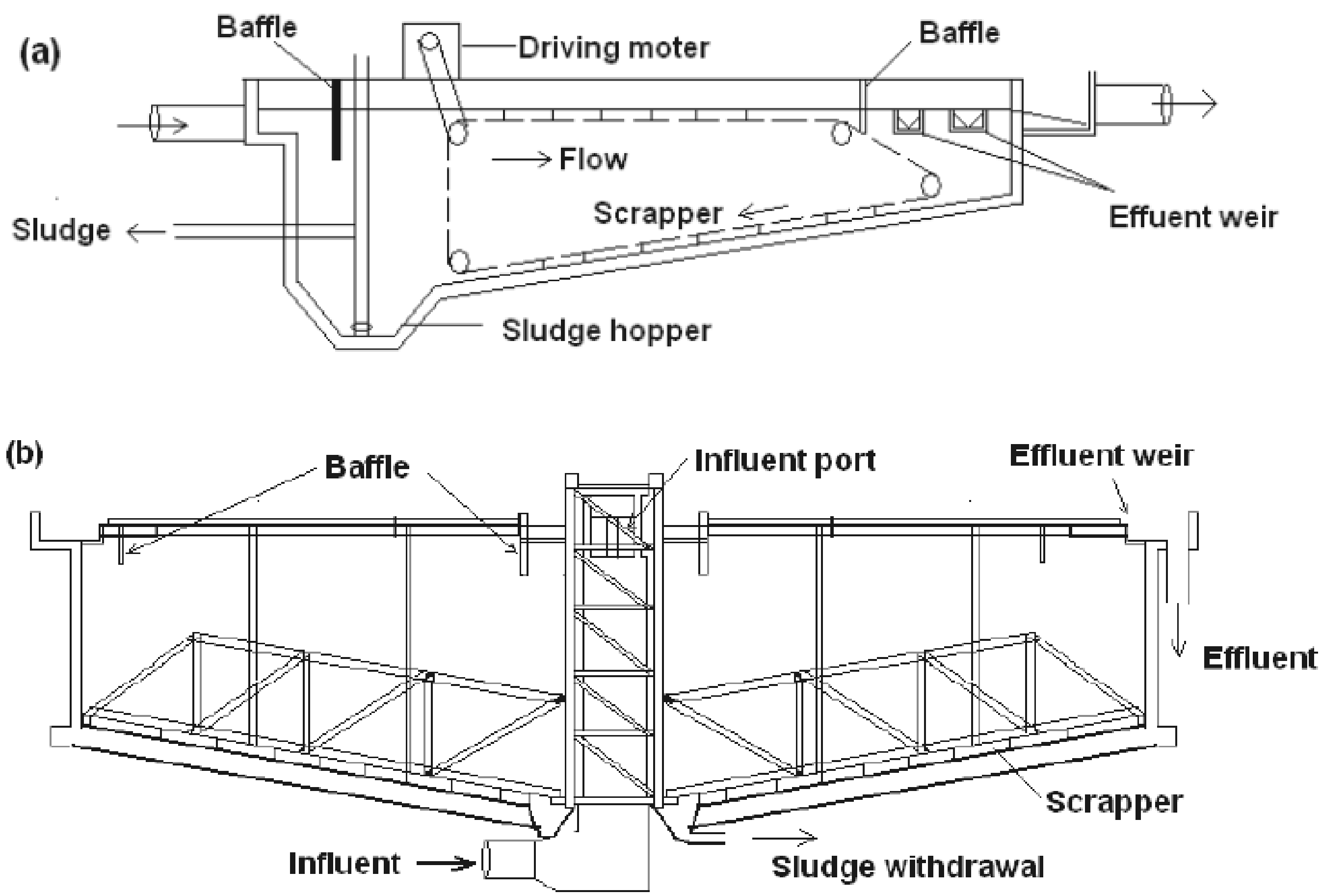


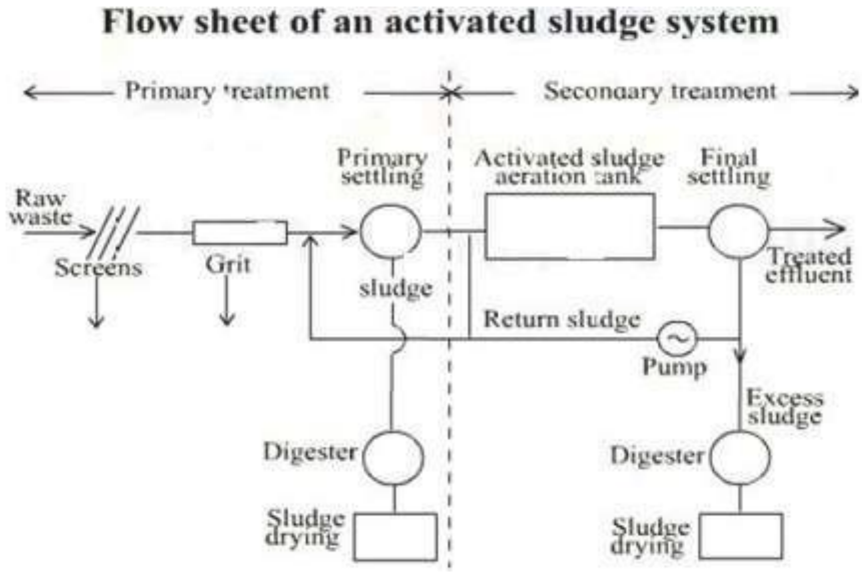
Figure (a) Rectangular and (b) Circular primary sedimentation tank

The scrapper velocity of 0.6 to 1.2 m/min (0.9 m/min typical) is used in rectangular tank and flight speed of 0.02 to 0.05 rpm (0.03 typical) is used in circular tank.

The detention time in PST could be as low as 1 h to maximum of 2.5 h. providing detention time of 1.5 to 2.5 h at average flow is a common practice. To avoid resuspension (scouring) of settled particles, horizontal velocities through the PST should be kept sufficiently low.

5.1.1 ACTIVATED SLUDGE PROCESS

The most common suspended growth process used for municipal wastewater treatment is the activated sludge process as shown in figure



Activated sludge plant involves:

1. Wastewater aeration in the presence of a microbial suspension,
2. Solid-liquid separation following aeration,
3. Discharge of clarified effluent,
4. Wasting of excess biomass, and return of remaining biomass to the aeration tank.

In activated sludge process wastewater containing organic matter is aerated in an aeration basin in which micro-organisms metabolize the suspended and soluble organic matter. Part of organic matter is synthesized into new cells and Part is oxidized to CO_2 and water to derive energy. In activated sludge systems the new cells formed in the reaction are removed from the liquid stream in t he form of a flocculent sludge i n settling tanks. A part of this settled biomass, described as activated sludge is returned to the aeration tank and the remaining forms waste or excess sludge.

Activated Sludge Process Variables

The main variables of activated sludge process are the mixing regime, loading rate, and the flow scheme.

Mixing Regime

Generally two types of mixing regimes are of major interest in activated sludge process: plug flow and complete mixing.

In the first one, the regime is characterized by orderly flow of mixed liquor through the aeration tank with no element of mixed liquor overtaking or mixing with any other element. There may be lateral mixing of mixed liquor but there must be no mixing along the path of flow.

In complete mixing, the contents of aeration tank are well stirred and uniform throughout. Thus, at steady state the effluent from the aeration tank has the same composition as the aeration tank contents.

The type of mixing regime is very important as it affects

1. Oxygen transfer requirements in the aeration tank,
2. Susceptibility of biomass to shock loads,
3. Local environmental conditions in the aeration tank, and
4. The kinetics governing the treatment process.

Flow Scheme

The f low scheme involves:

1. The pattern of sewage addition
2. The pattern of sludge return to the aeration tank and
3. The pattern of aeration.

Sewage addition may be at a single point at the inlet end or it may be at several points along the aeration tank. The sludge return may be directly from the settling tank to the aeration tank or through a sludge reaeration tank. Aeration may be at a uniform rate or it may be varied from the head of the aeration tank to its end.

Sludge characteristics

By analyzing the different characteristics of the activated sludge or the sludge quality, plant operators are able to monitor how effective the treatment plant's process is. Efficient operation is ensured by keeping accurate, up-to-date records; routinely evaluating operating and laboratory data; and troubleshooting, to solve problems before they become serious.

5.1.2 EXTENDED AERATION SYSTEM

It is an innovative activated sludge process using extended retention of biological solids to create an extremely stable, easily operated system. The capabilities of this unique technology far exceed ordinary extended aeration treatment. The process maximizes the stability of the operating environment and provides high efficiency treatment. The design ensures the lowest cost construction and guarantees operational simplicity. The system utilizes a longer sludge age than other aerobic systems. Sludge age, also known as SRT (Solids Retention Time) or MCRT (Mean Cell Residence Time), defines the operating characteristics of any aerobic biological treatment system. A longer sludge age dramatically lowers effluent BOD and ammonia levels, especially in colder climates.

The systems long sludge age process produces BOD levels of less than 10 mg/L and complete nitrification (less than 1 mg/L ammonia). Minor modifications to the system will extend its capabilities to denitrification and biological phosphorus removal.

System Construction

A major advantage of this system is its low installed cost. Most systems require costly in-ground concrete basins for the activated sludge portion of the process. This system can be installed in earthen basins, either lined or unlined. The fine bubble diffusers require no mounting to basin floors or associated anchors and leveling. These diffusers are suspended from the Bio-Flex floating aeration chains. The only concrete structural work required is for the simple internal clarifier(s) and blower/control buildings.

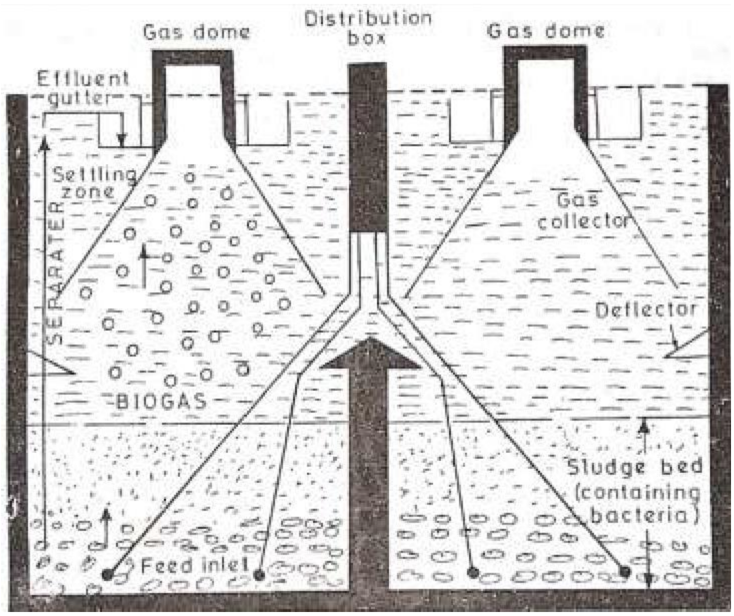
Aeration System Components

The ability to mix large basin volumes using minimal energy is a function of the unique BioFlex moving aeration chains and the attached BioFuser fine bubble diffuser assemblies. The gentle, controlled, back and forth motion of the chains and diffusers distributes the oxygen transfer and mixing energy evenly throughout the basin area. No additional airflow is required to maintain mixing.

5.2 UASB (UPFLOW ANAEROBIC SLUDGE BLANKET) REACTOR

The UASB reactor maintains a high concentration of biomass through the formation of highly settle able microbial sludge aggregate. The waste water flows upwards through alayer of very active sludge to cause anaerobic digestion of organics of the waste waterat the top of the reactor, these phase separation between gas-solid-liquid takes place anybiomass leaving the reaction zone is directly recirculated from the settling g zone. The process is suitable for both soluble waste waters as well as waste water containing particulate matter.

The large scale adoption of this technique for treating municipal waste waters is comparatively of recent origin .This reactor consists of an Up flowing treatment tank, provided with a feed inlet distribution system at the tank bottom. A gas solid-liquid separator (GSS) device is provided at the top to help provide a quiescent zone at the top of the reactor.



The wastewaters enter the tank from the bottom and flows upward through the sludge bed. The sludge bed develops micro-organisms capable of Flourishing in an oxygen deficient environment. The sludge bed (blanket) traps the suspended organics of the up moving wastewater. The suspended solids trapped in the sludge bed are degraded by the producing methane and CO 2(ie, biogas, which is a mixture of 65-70% methane, and 30-35% CO_2.The biogas produce of during the anaerobic decomposition reducing the BOD and suspended solids of the wastewater. The methane or biogas is collected at the top of the tank in a gas collector from Where it can be withdraw n for use as a by- product, while the water sludge mixture is made to enter a setting tank where the sludgemixture is made to enter a setting tank where the sludge settles down and f lows back into the bottom of the reactor.

The sludge will show good settling properties after an initial start up period, followed by granulation forming a sludge blanket or sludge bed in the lower part of the reactor. Retention of the bacteria contacting sludge in the reactor is one of the most important features of the UASB process. The bacteria in the sludge continue to perform their function of treating the incoming effluent. The continuous bacterial presence and activity enables retention time in the reactor to be reduced to about 6-8 hours, as compared to at least 30 hrs that is required in conventional sewage treatment systems. The treated effluent is collected in gutters, and discharged out of the reactor. The sludge is periodically shifted in to the drying beds to be used as a soil enriches, The methane generated can be used as a gas for domestic or industrial use it may also be used for generation of electricity for running the plant, after the approximated hydration and cleaning. This process can be reactivated even after the plant remains shut down for days or months, or after power breakdowns and interruptions in wastewater supply Like other high rate anaerobic systems.

The various advantages offered by UASB systems are

The space requirement of the system is quite comparable to that of an Activated sludge ie, about 0.5 acres per MLD, as compared to 2.5 acres per MLD required for oxidation ponds, and 1.5 acres for Aerated lagoons.

The capital cost investment of such a plan it s about Rs.20 lakh/MLD as compared oabout Rs.35 lakh/MLD for an Activated sludge plant, Rs.75 lakh/MLD for oxidation ponds and Rs.15lakh/MLD f or Aerated lagoons.

The system requires lesser and simpler electromagnetic parts as compared to the ones required in an Activated sludge plant, leading to lower operation and Maintenance cost.

Electricity consumption in this system , like all anaerobic systems is quite low, and the system is quite capable of withstanding long power failures.

The sludge Production system is low, and the produced sludge is having quick dewatering characteristics.

The system enables quicker sludge digestion, as compared to the conventional digestors.

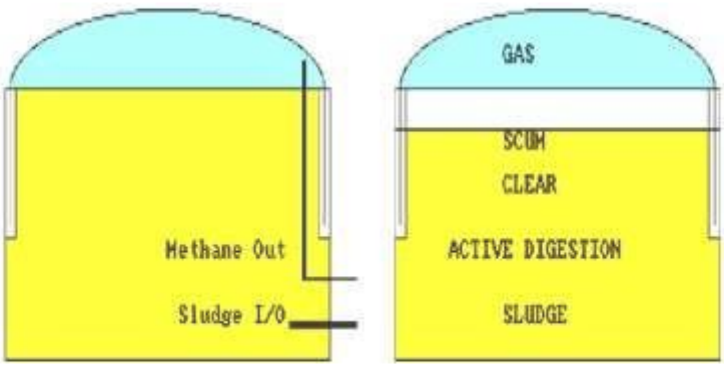
Biogas is produced in the system as a by-product, which can be used to produce electricity to run the system.

BIOGAS RECOVERY FROM SLUDGE:

In India about 30% of energy consumed by public is biological in nature. The fermentation of organic waste is carried out between 35 to 50^{0}C. Biogas, as a renewable energy, can be produced from a variety of organic raw materials and utilized for various energy services, such as heat, combined heat and power or as a vehicle fuel. Biogas can be produced by anaerobic digestion or fermentation of biodegradable materials such as biomass, manure, sewage, municipal waste, green waste, plants material and energy crops. Biogas is currently produced mostly by digestion of sewage treatment sludge, with minor contributions from fermentation of gasification of solid waste.

In today‘s energy demanding life style, biogas as the typical renewable as well as eco- friendly new energy source will replace fossil fuel inevitably. Anaerobic digestion (AD) or methane fermentation is an economical and eco-friend process for biomass, organic matter conversion to produce biogas; which mainly consists of methane and carbon dioxide. It is a biological conversion of complex substrates into biogas and inert digestate by microbial activity in oxygen free environment.

The digestion process involves four main steps, namely hydrolysis, acidogenesis, acetogenesis and methanogenesis. Sewage sludge used as substrate in this study was collected from municipal waste treatment plant (WWTP). Sludge sample was characterized before use. The used raw sludge was freshly collected and rich in anaerobic bacteria. At the end of the digestion, an average volume of biogas generated was evaluated.



The gas is collected in a steel gas holder placed at the top of digestion tank; the average composition of biogas is as follows Methane-55%, Carbondioxide 35%, Hydrogen 7.4% and Nitrogen 2.6%. Biogas improves local sanitation and health. The main objective during AD is to recover methane gas which could serve as combustible in various area of the economy, including generation of electricity, heating, and in kitchen.

5.2.1 SEQUENCING BATCH REACTORS (SBR)

The sequencing batch reactor is a fill and draw activated sludge system for waste water treatment. In this system, wastewater is added to a single “batch” reactor, treated to remove undesirable components, and then discharged. Equalization, aeration, and clarification can all be achieved using a single batch reactor. To optimize the performance of the system, two or more batch reactors are used in a predetermined sequence of operations.

SBR systems have been successfully used to treat both municipal and industrial wastewater. They are uniquely suited for wastewater treatment applications characterized by low or intermittent flow conditions.

An SBR serves as an equalization basin when the vessel is filling with wastewater, enabling the system to tolerate peak flows or peak loads in the influent and to equalize them in the batch reactor. In many conventional activated sludge systems, separate equalization is needed to protect the biological system from peak flows, which may wash out the biomass, or peak loads, which may upset the treatment process.

APPLICABILITY

SBRs are typically used at flow rates of 5 MGD or less. The more sophisticated operation required at larger SBR plants tends to discourage the use of these plants for large flow rates. As these systems have a relatively small footprint, they are useful for areas where the available land is limited.

In addition, cycles within the system can be easily modified for nutrient removal in the future, if it becomes necessary. This makes SBRs extremely flexible to adapt to regulatory changes for effluent parameters such as nutrient removal. SBRs are also very cost effective if treatment beyond biological treatment is required, such as filtration.

ADVANTAGES AND DISADVANTAGES

Some advantages and disadvantages of SBRs are listed below:

Advantages:

a) Equalization, primary clarification (in most cases), biological treatment, and secondary clarification can be achieved in a single reactor vessel.

b) Operating flexibility and control.

c) Minimal footprint.

d) Potential capital cost savings by eliminating clarifiers and other equipment.

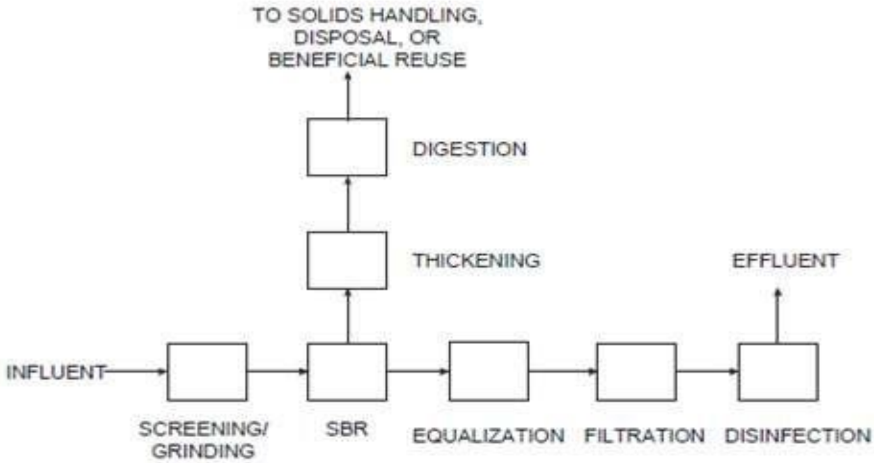
Disadvantages

a) A higher level of sophistication is required (compared to conventional systems), especially for larger systems, of timing units and controls.

b) Higher level of maintenance (compared to conventional systems) associated with more sophisticated controls, automated switches, and automated valves.

c) Potential of discharging floating or settled sludge during the DRAW or decant phase with some SBR configurations.

d)Potential plugging of aeration devices during selected operating cycles, depending on the aeration system used by the manufacturer.



Process flow diagram for a typical SBR

Construction

Construction of SBR systems can typically require a smaller footprint than conventional activated sludge systems because the SBR often eliminates the need for primary clarifiers. The SBR never requires secondary clarifiers. The size of the SBR tanks themselves will be site specific, however the SBR system is advantageous if space is limited at the proposed site.

Tank and Equipment Description

The SBR system consists of a tank, aeration and mixing equipment, a decanter, and a control system. The central features of the SBR system include the control unit and the automatic switches and valves that sequence and time the different operations. SBR manufacturers should be consulted for recommendations on tanks and equipment.

It is typical to use a complete SBR system recommended and supplied by a single SBR manufacturer. It is possible, however, for an engineer to design an SBR system, as all required tanks, equipment, and controls are available through different manufacturers. This is not typical of SBR installation because of the level of sophistication of the instrumentation and controls associated with these systems.

The SBR tank is typically constructed with steel or concrete. For industrial applications, steel tanks coated for corrosion control are most common while concrete tanks are the most common for municipal treatment of domestic wastewater.

For mixing and aeration, jet aeration systems are typical as they allow mixing either with or without aeration, but other aeration and mixing systems are also used. Positive displacement blowers are typically used for SBR design to handle wastewater level variations in the reactor.

PERFORMANCE

The performance of SBRs is typically comparable to conventional activated sludge systems and depends on system design and site specific criteria. Depending on their mode of operation, SBRs can achieve good BOD and nutrient removal. For SBRs, the BOD removal efficiency is generally 85 to 95 percent.

SBR manufacturers will typically provide a process guarantee to produce an effluent of less than:

i) 10 mg/L BOD

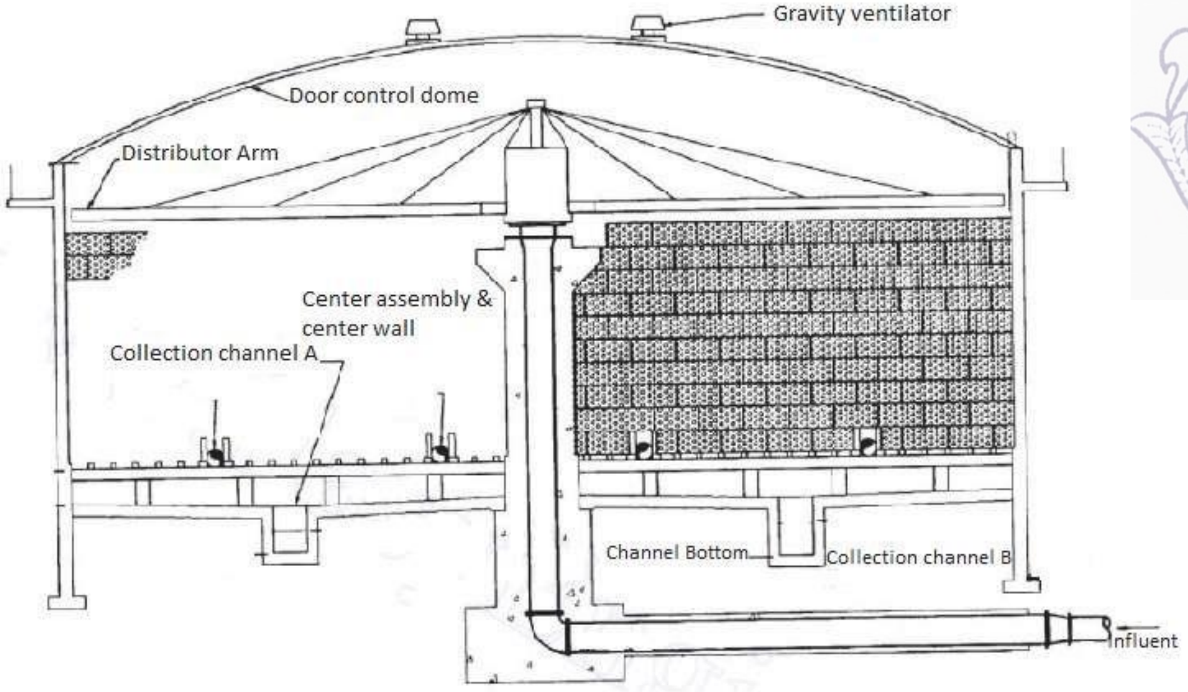
ii) 10 mg/L TSS

5.2.2 TRICKLING FILTERS

Trickling filter is an attached growth process i.e. process in which microorganisms responsible for treatment are attached to an inert packing material. Packing material used in attached growth processes include rock, gravel, slag, sand, redwood, and a wide range of plastic and other synthetic materials.

Process Description

1. The wastewater in trickling filter is distributed over the top area of a vessel containing non-submerged packing material.
2. Air circulation in the void space, by either natural draft or blowers, provides oxygen for the microorganisms growing as an attached biofilm.
3. During operation the organic material present in the wastewater is metabolized by the biomass attached to the medium. The biological slime grows in thickness as the organic matter abstracted from t he f lowing wastewater is synthesized into new cellular material.
4. The thickness of the aerobic layer is limited by the depth of penetration of oxygen into the microbial layer.
5. The micro-organisms near the medium face enter the endogenous phase as the substrate is metabolized before it can reach the micro-organisms near the medium face as a result of increased thickness of the slim layer and lose their ability to cling to the media surface. The liquid then washes the slime of the medium and a new slime layer starts to grow. This phenomenon of losing the slime layer is called sloughing.
6. The sloughed off film and treated wastewater are collected by an under drainage which also allows circulation of air through filter. The collected liquid is passed to a settling tank used for solid- liquid separation.



Types of Filters

Trickling filters are classified as high rate or low rate, based on the organic and hydraulic loading applied to the unit.

S.No	Design Feature	Low Rate Filter	High Rate Filter
1.	Hydraulic loading, $m^3/m^2.d$	1 - 4	10 - 40
2.	Organic loading,kg BOD / m^3.d	0.08 - 0.32	0.32 - 1.0
3.	Depth, m.	1.8 - 3.0	0.9 - 2.5
4.	Recirculation ratio	0	0.5 - 3.0 (domestic wastewater) upto 8 for strong industrial wastewater.

1. The hydraulic loading rate is the total flow including recirculation applied on unit area of the filter in a day, while the organic loading rate is the 5 day 20°C BOD, excluding the BOD of the recircular, applied per unit volume in a day.

2. Recirculation is generally not adopted in low rate filters.

3. A well operated low rate trickling filter in combination with secondary settling tank may remove 75 t o 90% BOD and produce highly nitrified effluent It is suitable for treatment of low t o medium strength domestic wastewaters.

4. The high rate trickling filter, single stage or two stage are recommended for medium

to relatively high strength domestic and industrial wastewater. The BOD removal efficiency is around 7 5t o 90% but the effluent is only partially nitrified.

5. Single stage unit consists of a primary settling tank filter, secondary settling tank and facilities for recirculation of the effluent. Two stage filters consist of two filters in series with a primary settling tank, an intermediate settling tank which may be omitted in certain cases and a final settling tank.

5.3 OXIDATION POND

Waste stabilization ponds (WSPs) are sanitation technologies that consist of open basins that use natural processes to treat domestic wastewater, septage, and sludge, as well as animal or industrial wastes. They can be used in centralized or semi-centralized sewerage systems, they can also be used to treat fecal sludge from onsite dry sanitation systems, or as onsite water-based sanitation systems serving a single building or home. The most common types of WSPs are anaerobic ponds, facultative ponds, maturation or polishing ponds, aerated ponds, and high-rate algal ponds (HRAPs)

Some pathogen removal is accomplished in anaerobic, facultative, aerated ponds and HRAPs, even though their primary function is to remove and stabilize organic matter. The primary function of maturation and polishing ponds however, is to remove and inactivate pathogens.

WSP systems require large areas of open land, making them ideal in smaller towns and rural settings, though they are used successfully in many urban environments as well, often in combination with other sanitation technologies. One of the biggest advantages of WSPs is that they are easy and inexpensive to operate and maintain, and generally do not rely on mechanized equipment or expensive material.

Waste stabilization ponds (WSPs) are open basins enclosed by earthen embankments, and sometimes fully or partially lined with concrete or synthetic geofabrics. They employ natural processes to treat domestic wastewater, septage, and sludge, as well as animal or industrial wastes. They can be used in centralized or semi-centralized sewerage systems, serving cities or towns; they can also be used as onsite systems serving a single entity (e.g., highway rest area, community center, etc.)

Inputs and Outputs for Waste Stabilization Ponds:

WSPs can be used to treat a variety of water and waste streams, thus the inputs may include wastewater, septage, latrine pit contents, and/or sludge from other wastewater treatment processes.

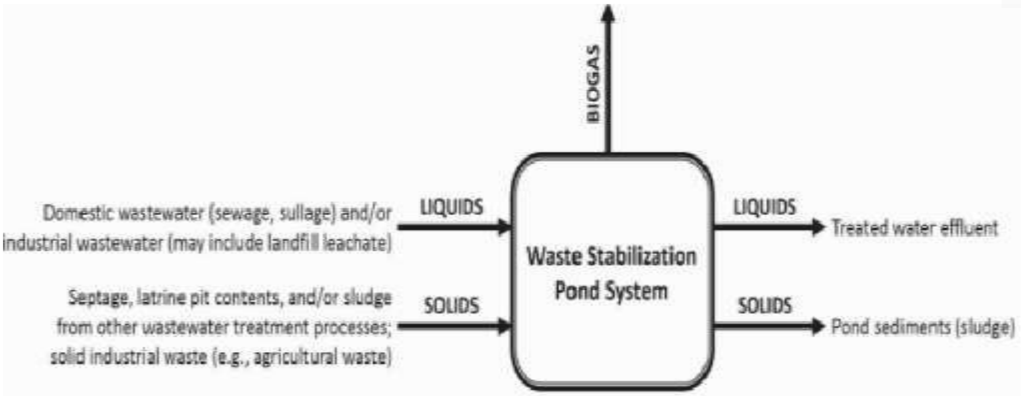
WSPs may receive untreated wastewater that has gone through preliminary treatment (e.g. screening and grit removal), or they may receive secondary effluent from some other treatment process, such as anaerobic reactors, activated sludge, or trickling filters.

The outputs from WSP systems include the treated effluent (liquid), sludge/sediments (solids), and biogas. The treated liquid effluent from WSPs is often continuously discharged; however, operators of some systems (especially in colder climates) may stop discharging for months at a time, allowing the ponds to fill up and discharging once the temperature gets warmer (this extra retention time makes up for the slower rate of treatment during colder months).

Sludge removed from WSPs is contaminated with pathogens and needs to be safely managed (to prevent exposure) or treated (to reduce the concentration of pathogens). Refer to the chapter on Sludge Management.

Factors Affecting Pathogens in Waste Stabilization Ponds:

Different factors affect different types of pathogens in different ways. The most important factor for the removal of viral and bacterial pathogens is sunlight exposure, although other factors such as temperature, dissolved oxygen and pH are also important. Sedimentation, hydraulic efficiency, sunlight exposure, and physical chemical factors (including temperature and pH) are all important factors for the removal of protozoan pathogens, though sedimentation is perhaps the most important.



Typical inputs and outputs from waste stabilization pond systems

Sedimentation

WSP systems have hydraulic retention times on the order of days, weeks, or even months, which allows large, dense particles to settle. Sedimentation is more effective in WSPs with less turbulence. Ponds should be designed to maintain quiescent conditions that approach laminar flow.

The size and density of pathogens and particles determines their settling velocities. Bacteria and viruses will not settle in WSPs unless they are attached to larger, denser particles. Only a small percentage of viruses attach to WSP particles, and they mostly attach to particles that are too small to settle.

Physical-Chemical and Microbiological Factors

The most important physical-chemical factors for pathogen inactivation are pH, temperature and dissolved oxygen in the presence of dissolved organic matter. Most bacterial pathogens are vulnerable to high pH.

Problem:

Design an oxidation pond for treating sewage from a hot climatic residential colony with 5000 persons contributing sewage at120 lit/capita/day. The 5 day BOD of sewage is 300mg/lit.

<u>Given data</u>

Population of residential colony = 5000

Sewage /capita/day =120 lit

5Day BOD of sewage=300 mg/lit=300×10^{-6} Kg/lit

<u>Solution</u>

Quantity of sewage treated/ day= 5000x120

=600000 liters

=$60000/10^6$

=0.6 Million Liters

The BOD content/ day = 0.6x300

=180Kg

Assuming the organic loading in pond as 300Kg/hectare

$$\text{Surface area required} = \frac{\text{BOD content per day}}{\text{Organic loading}}$$

= 180/300= 0.6 hec

=0.6x10000= $6000 m^2$

Surface area required= $6000 m^2$

Assuming the length of tank twice the width L=2b

2bxb=6000

b=55m

L=2x55=110m

Assuming effective depth as 1.2m

Volume= 110x55x1.2 = $7260 m^3$

$$\text{Detention time} = \frac{\text{Volume}}{\text{Sewage flow per day}}$$

=7260/0.6x1000

Detention time = 12 days

Hence use an oxidation pond with length 110m, width 55m , overall depth1.2+1=2.2m and the detention period of 12 days.

Design of inlet and outlet

Assuming the average velocity of sewage as 0.9m/sec and daily flow for 8 hours only

$$\text{Discharge}= \frac{\text{Quantity of sewage per day}}{\text{Daily flow in hrs}}$$

$=600\ m^3/\ 8x60x60$ sec

Discharge= 0.0208 m^3/sec

Q=AV

0.0208=Ax0.9

A=0.023m^2

Inlet pipe diameter $A = \pi d^2/4$

0.023= $\pi d^2/4$

d= 0.172m=17.2cm

Diameter of outlet pipe may be taken as 1.5 times the inlet diameter

= 1.5x0.172=0.25m

Diameter of outlet pipe=25cm.

OXYGEN SAG CURVE AND ITS IMPORTANCE:

In a running polluted stream exposed to the atmosphere, the deoxygenation as well as there-oxygenation goes hand in hand. If de-oxygenation is more rapid than the reoxygenation, an oxygen deficit results. (Note; if the D.O content becomes zero, anaerobic conditions will no longer be maintained and putrefaction will set in) The amount of resultant oxygen deficit can be obtained by algebraically adding the de-oxygenation and re-oxygenation curves. The resultant curve so obtained is called the oxygen sag curve or the oxygen deficit curve. From this curve the oxygen deficit (D) and oxygen balance (i.e 100-D) percent in a steam after a certain lapse of time, can be found out.

It can also be seen that when the de-oxygenation rate exceeds the reoxygenation rate, the oxygen sag curve shows increasing deficit of oxygen, but when both the rate becomes equal, the critical point is reached, and then finally when the rate of de-oxygenation falls below that of re-oxygenation, the oxygen deficit goes on decreasing till becoming zero.

DEOXYGENATION AND REAERATION:

In the polluted stream, the D.O content goes on reducing due to decomposition of volatile organic matter. The rate of deoxygenation depends upon the amount of the organic matter remaining to be oxidisied at he given time as well as on the temperature of reaction. In order to counter- balance the consumption of DO due to de-oxygenation, atmosphere supplies oxygen to the water, and the process is called re-oxygenation. The rate at which the oxygen is supplied by the atmosphere depends.

1. The depth of the receiving water
2. The condition of the body of water
3. The saturation deficit or the oxygen deficit
4. The temperature of water

5.3.1 MEMBRANE BIOREACTORS

The technologies most commonly used for per-forming secondary treatment of municipal wastewater rely on microorganisms suspended in the wastewater to treat it. Although these technologies work well in many situations, they have several drawbacks, including the difficulty of growing the right types of microorganisms and the physical requirement of a large site.

The use of microfiltration membrane bioreactors (MBRs), a technology that has become increasingly used in the past 10 years, overcomes many of the limitations of conventional systems. These systems have the advantage of combining a suspended growth biological reactor with solids removal via filtration.

The membranes can be designed for and operated in small spaces and with high removal efficiency of contaminants such as nitrogen, phosphorus, bacteria, bio-chemical oxygen demand, and total suspended solids.

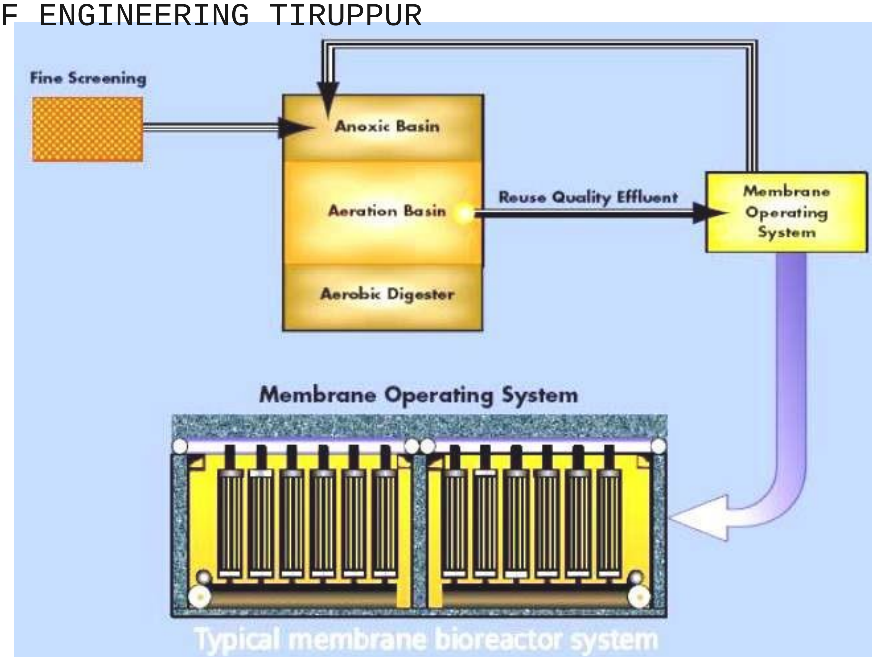
The membrane filtration system in effect can replace the secondary clarifier and sand filters in a typical activated sludge treatment system. Membrane filtration allows a higher biomass concentration to be maintained, thereby allowing smaller bioreactors to be used.

Applicability

For new installations, the use of MBR systems allows for higher wastewater flow or improved treatment performance in a smaller space than a conventional design, i.e., a facility using secondary clarifiers and sand filters.

Historically, membranes have been used for smaller-flow systems due to the high capital cost of the equipment and high operation and maintenance (O&M) costs. Today however, they are receiving increased use in larger systems. MBR systems are also well suited for some industrial and commercial applications.

Although MBR systems provide operational flexibility with respect to flow rates, as well as the ability to readily add or subtract units as conditions dictate, that flexibility has limits. Membranes typically require that the water surface be maintained above a minimum elevation so that the membranes remain wet during operation.



Membrane Care

The key to the cost-effectiveness of an MBR system is membrane life. If membrane life is curtailed such that frequent replacement is required, costs will significantly increase. Membrane life can be increased in the following ways:

- Good screening of larger solids before the membranes to protect the membranes from physical damage.
- Throughput rates that are not excessive, i.e., that do not push the system to the limits of the design.

Advantages and disadvantages

The advantages of MBR systems over conventional biological systems include better effluent quality, smaller space requirements, and ease of automation.

Specifically, MBRs operate at higher volumetric loading rates which result in lower hydraulic retention times. The low retention times mean that less space is required compared to a conventional system.

The primary disadvantage of MBR systems is the typically higher capital and operating costs than conventional systems for the same through-put.

O&M costs include membrane cleaning and fouling control, and eventual membrane replacement. Energy costs are also higher because of the need for air scouring to control bacterial growth on the membranes.

5.3.2 SELF PURIFICATION TREATMENTS

Self purification of natural streams:

When the waste water or the effluents discharged in to a natural stream, the organic matter is broken by bacteria to ammonia, nitrate, sulphate, carbon dioxide etc In this process of oxidation, the DO content of natural water is utilized. Due to this, deficiency of DO is created. As the excess organic matter is stabilized, the normal cycle will be restabilised in a process known as self purification where in the oxygen is replenished by its reaeration by wind.

Water quality standards are often based upon maintenance of some minimum dissolved oxygen concentration which will protect the natural cycle in the stream while taking advantage of its natural assimilative capacity.

Actions involved in the self purification are physical, chemical and biological in nature

1. Dilution

2. Dispersion due to currents

3. Sedimentation

4. Oxidation

5. Reduction

6. Temperature

7. Sunlight

1. Dilution

When waste water is discharged in to the receiving water, dilution takes place due to which the concentration of organic matter is reduced and the potential nuisance of sewage is also reduced. When the dilution ratio is high, large quantities of DO are always available which will reduce the chances of putrefication and pollutional effect. Aerobic condition will always exist because of dilution.

2. Dispersion due to currents

Self purification of stream largely depends on currents which will readily disperse the wastewater in the stream preventing locally the high concentration of pollutants. High velocity improves reaeration which reduces the concentration of pollutants. High velocity improves reaeration which reduces the time of recovery, though length of stream affected by waste water is increased.

3. Sedimentation

If the stream velocity is lesser than the scour velocity of particles, sedimentation of the particles will take place which will have two effects,

a. The suspended particles will contribute largely to oxygen demand which will be removed by settling and hence water quality to the downstream will be increased.

b. Due to settled solids, Anaerobic decomposition may take place.

4. Oxidation

The organic matter present in the waste water by aerobic bacteria utilizing DO of the natural water, This process prevails till complete oxidation of organic matter. The stream which is capable of absorbing more oxygen rapidly through reaeration etc. and purify heavily polluted water in a short time.

5. Reduction

The reduction occurs in the streams due to hydrolysis of the organic matter biologically or chemically.Anaerobic bacteria split the organic matter in to liquids and gases thus paving way for their ultimate stabilization by oxidation.

6. Temperature

At low temperature the activities of bacteria is slow and hence rate of decomposition will also be slow though DO will be more because of increased solubility of oxygen in water. At higher temperature, however the self purification takes lesser time though t he quality of DO will be less.

7. Sunlight

It helps certain microorganisms to absorb co2 and give out oxygen, though assisting in self purification. Sunlight act as a disinfectant and stimulate the growth of algae which produce oxygen during day light but utilize oxygen at night hence wherever there is algal growth, the water may be supersaturated in DO during daylight hours though anaerobic condition exist in it.

Self Purification Process:

When sewage is discharges into a natural body of water, the receiving water gets polluted due to waste products, present in sewage effluents. But the conditions do not remain so for ever, because the natural process of purification such as dilution, sedimentation, oxidation-reduction in sunlight, etc, go on acting upon the pollution elements, and bring back the water in to its original condition. The automatic purification of polluted water, in due course is called the self purification phenomenon. However if the self purification is not achieved successfully due to either too much of pollution discharge in to it or due to other causes, the river water itself will get polluted which in turn, may also pollute the sea where the river outfalls.

Factors influencing self purification process:

1. Temperature

2. Turbulence

3. Hydrography such as the velocity and surface expanse of the river stream.

4. Rate of reaeration etc.

Temperature:

Besides affecting the dilution and sedimentation rates, the temperature also affects the rate of biological and chemical activities, which are enhanced at high temperatures and depressed at lower temperatures. The dissolved oxygen content of water, which is very essential for maintaining aquatic life and anaerobic conditions (so as to avoid the anaerobic decomposition and subsequent nuisance caused by the eruption of foul odors) is also influenced by temperature. At higher temperature the capacity to maintain the D.O concentration is low.

Turbulence:

while the rate of biological and chemical activities are high, causing thereby rapid depletion of D.O this is likely to lead to anaerobic conditions, when the pollution due to putrescible organic matter is heavy. The turbulence in the body of water helps in breaking the surface of the stream of lakes, and helps in rapid re-aeration from the atmosphere. Thus it helps in maintaining aerobic conditions in the river stream, and in keeping it clean. Too much of turbulence, however is not desirable, because it cannot be at the bottom sediment increases the turbidity and retards algae growth, which is useful in reaeration process. Wind and under current in lakes and oceans cause turbulences which affect their self-purification.

The hydrography:

Affects the velocity and surface expanse of the river stream, High velocities cause turbulence and rapid reaeration, while large surface expanse(for the same cubic contents) will also have the same effects.

Dissolved oxygen:

The large amount of dissolved oxygen present in water, the better and earlier the self purification will occur. The amount and type of organic matter and biological growth present in water will also affect the rate of purification. Algae which absorbs carbon dioxide and gives out oxygen, is thus very helpful in the self purification process.

The rate of Reaeration:

The rate at which the D.O deficiency is replenished, will considerably govern the self purification process. The greater is the rate, the quicker will be self-purification, and there will be no chances of development of anaerobic conditions.

5.4 OPERATION AND MAINTENANCE ASPECTS OF SEWAGE TREATMENT PLANT

OBJECTIVES OF SLUDGE TREATMENT:

- To reduce the water content in the sludge and make it easier for treatment and disposal
- To destroy all the pathogens
- To reduce the volume of sludge
- To stabilize the organic matter

FORMS OF SLUDGE:

• Primary sludge – When raw sewage is settled in a primary clarifier, the suspended solids settle down by gravity. These are drawn out from the conical floor of the clarifier. This is called primary sludge (PS). It will have mostly organic substances and also inorganic substances. If it is stored, the organic substances will undergo anaerobic reaction as in Figure 5.2. This will result in production of Methane and Hydrogen Sulphide gases.

• Secondary sludge – When the sewage is aerated in aeration tanks, biological microorganisms grow and multiply. The aerated liquid is called the mixed liquor. It is settled in secondary clarifiers to separate the microorganisms by gravity. These are drawn out from the conical floor of the clarifier. This is called secondary sludge.

• Return sludge – A major portion of the secondary sludge is returned to the aeration tank for seeding the microorganisms. This is called return sludge (RS).

• Excess sludge – A small portion of secondary sludge is wasted. This is equal to secondary sludge minus return sludge. This is called excess sludge (ES) on waste sludge (WS).

• Chemical sludge – When raw sewage or secondary treated sewage is subjected to chemical precipitation, the resulting sludge is called chemical sludge (CS).

UNIT OPERATIONS AND PROCESSES:

Waste water treatment is any operation / process or combinations of operations and processes that can reduce the objectionable properties of waste water and render it less dangerous. Waste water treatment is a combination of physical, chemical and biological processes.

Methods of treatment in which application of physical forces predominate, are known as unit operations.

Methods of treatment in which chemical or biological activities are involved, known as unit processes.

The unit operations approach in water and waste water treatment has following advantages:

1. Gives better understanding of the processes and the capabilities of these processes in attaining the objectives.
2. Helps in developing mathematical and physical models of treatment mechanisms and the consequent design of treatment plants.
3. Helps in coordination of effective treatment procedure to attain the desired plant performance.

PHYSICAL UNIT OPERATIONS

OPERATION	APPLICATION
1. Screening	Removal of coarse and settleable solids bysurface straining
2. Comminution	Grinding of coarse solids
3. Flow Equalisation	Equalisation of flow and mass loadings ofBOD suspended solids.
4. Mixing	Mixing of chemicals and gases with waste water and maintaining solids in suspension

5. Flocculation	Promotion of aggregation of smaller particles into larger ones.
6. Sedimentation	Removal of settleable solids and thickeningof sludge.
7. Floatation	Removal of finely divided suspended solidsand particles. Also thickens biological sludge.
8. Filtration	Removal of fine residual suspended solids remaining after biological or chemical treatment.
9. Micro screening	Same as filtration. Also removal of algaefrom stabilization pond effluents

CHEMICAL UNIT PROCESSES

PROCESS	APPLICATION
1. Chemical Precipitation	Removal of phosphorous and enhancement of suspended solidsremoval in primary sedimentation
2. Gas Transfer	Addition and removal of gases
3. Adsorption	Removal of organics
4. Disinfection	Disinfection of disease causingorganisms
5. De chlorination	Removal of total combined chlorineresiduals
6. Miscellaneous	Achievement of specific objectives in waste water treatment

BIOLOGICAL UNIT PROCESSES

Biological unit processes are those in which removal of contaminants are brought about by biological activity in biological treatment of waste water, the objectives are to coagulate and remove the non settleable colloidal solids and to stabilize the organic matter. The waste water is generally from three sources

(i) domestic waste water (ii) agricultural return waste water (iii) industrial waste water

For domestic waste water, the objectives are to remove various nutrients, specifically nitrogen and phosphorous, which are otherwise capable of stimulating growth of aquatic plants.

Biological processes are classified by the oxygen dependence of the primary microorganisms responsible for waste treatment.

Aerobic processes:

Biological treatment process that occurs in the presence of dissolved oxygen. The bacteria that can survive in the presence of DO are known as obligate aerobes. The aerobic process include the following:

1. Activated sludge process
2. Trickling filters

Anaerobic processes: Involves the decomposition of organic or inorganic matter in the absence of molecular oxygen

Maintenance Scheduling:

• Maintenance of each equipment is done as the recommendations of manufacturer.

• A History card is maintained for each equipment so that record is maintained for equipment performance and maintenance.

• Good housekeeping is an important aspect of plant operation.

Screening Chamber & Wet well:

• Regular Cleaning
• Disposal of Screenings
• Washing of Bar Screens
• Washing sludge layer from walls using water jet
• Desilting of wet well once a year

Receiving Chamber & Fine Screens:

• Should be scoured minimum once in a week.
• Fine Screens should be kept clean of all obstructions. If the screens are of mat type, its operation should be adjusted such that a mat is always on the screen.

Grit chamber:

• Should be used one at a time, alternatively every day.
• Should be cleaned every day.
• Proper & efficient removal of silt in grit channel will improve the functioning of treatment.

SCREENING:

A screen is a device with openings for removing bigger suspended or floating matter in sewage which would otherwise damage equipment or interfere with satisfactory operation of treatment units.

Types of Screens:

Coarse Screens

Coarse screens also called racks, are usually bar screens, composed of vertical or inclined bars spaced at equal intervals across a channel through which sewage flows. Bar screens with relatively large openings of 75 to 150 mm are provided ahead of pumps, while those ahead of sedimentation tanks have smaller openings of 50 mm.

Bar screens are usually hand cleaned and sometimes provided with mechanical devices. These cleaning devices are rakes which periodically sweep the entire screen removing the solids for further processing or disposal.

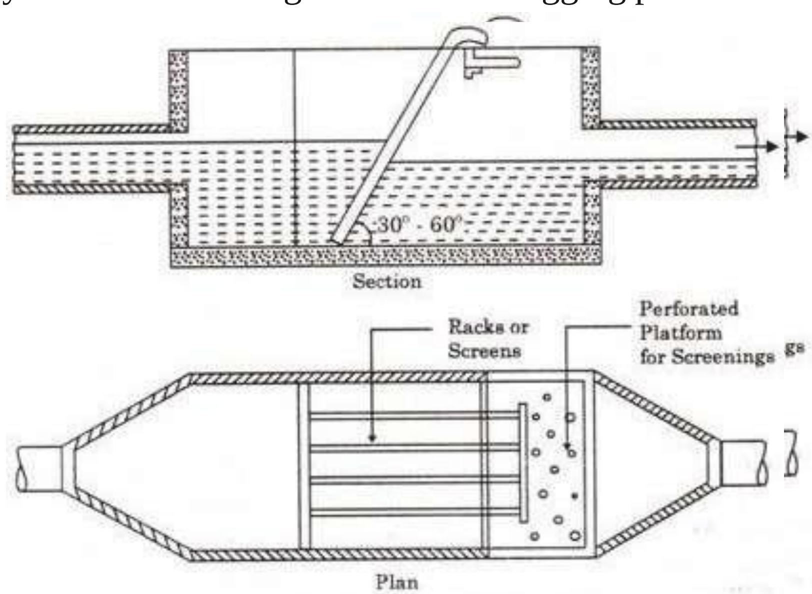
Hand cleaned racks are set usually at an angle of 45 °to the horizontal to increase the effective cleaning surface and also facilitate the raking operations. Mechanical cleaned racks are generally erected almost vertically. Such bar screens have openings 25% in excess of the cross section of the sewage channel.

Medium Screen

Medium screens have clear openings of 2 0t o 50 mm. Bar are usually 10 mm thick on the upstream side and taper slightly to the downstream side. The bars used for screens are rectangular in cross section usually about 10 x 50 mm, placed with larger dimension parallel to the flow.

Fine Screens

Fine screens are mechanically cleaned devices using perforated plates; woven wire cloth or very closely spaced bars with clear openings of less than 20 mm. Fine screens are not normally suitable for sewage because of clogging possibilities.



Bar Screen with Chamber

GRIT CHAMBER:

Grit is the heavy inorganic fraction of the wastewater solids. It includes road grit, sand, eggshells, ashes, charcoal, glass and pieces of metal; it may also contain some heavy organic matter such as seeds and coffee grounds. Grit has an average relative density of ~2.5 and thus it has a much higher settling velocity than organic solid s(~30 mm/s, compared with ~3 mm/s). There are two basic types of grit removal plant: constant velocity grit channels and the various proprietary grit tanks or traps available commercially.

Principle of Working of Grit Chamber

Grit chambers are like sedimentation tanks, designed to separate the intended heavier inorganic materials (specific gravity about 2.65) and to pass forward the lighter organic materials. Hence the flow velocity should neither be too low as to cause the settling of lighter organic matter, nor should it be too high as no to cause the settlement of the silt and grit present in the sewage. This velocity is called "differential sedimentation and differential scouring velocity".

The scouring velocity determines the optimum flow through velocity. This may be explained by the fact that the critical velocity of flow ' vc' beyond which particles of a certain size and density once settled, may be again introduced in to the stream of flow it should always be less than the scouring velocity of grit particles. The critical velocity of scour is given by Schield's formula:

$$V = 3t\ o\ 4.5(g(Ss - 1) d) 1/2$$

A horizontal velocity of flow of 15 t o 30 cm/sec is used at peak flows. This same velocity is to be maintained at all fluctuation of flow to ensure that only organic solids and not the grit is scoured from the bottom.

Horizontal Velocity in Flow Though Grit Chamber:

The settling of grit particles in the chamber is assumed as particles settling as individual entities and referred as Type – I settling. The grit chamber is divided in four compartments as inlet zone, outlet zone, settling zone and sludge zone.

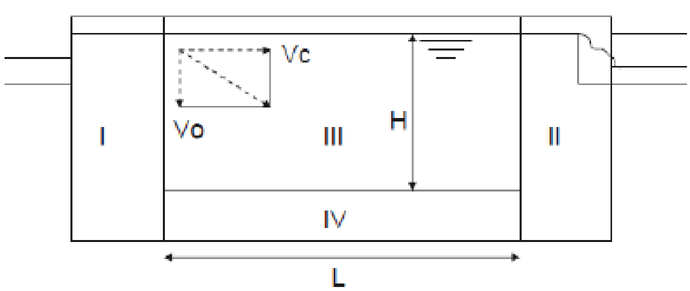


Figure: compartments of Grit chamber

Zone – I:
Inlet zone: This zone distributes the incoming wastewater uniformly to entire cross section of the grit chamber.
Zone – II:
Outlet zone: This zone collects the wastewater after grit removal.
Zone – III:
Settling zone: In this zone settling of grit material occurs. Zone – IV:
Sludge zone: This is a zone where settled grit accumulates.

L – Length of the settling zone
H – Depth of the settling zone
v – Horizontal velocity of wastewater
Vo – Settling velocity of the smallest particle intended to be removed in grit chamber.

Now, if Vs is the settling velocity of any particle, then
For Vs greater than equal to Vo these particles will be totally removed,
For Vs than less Vo, these particles will be partially removed,

Disposal of Grit:

Considerable quantities of grit will be collected at the sewage treatment plant, about 0.004 to 0.2 m3/ML. Quantity of grit will be more particularly for combined system. Necessary arrangement should be made at the treatment plant for collection, storage and disposal of this grit matter.
The grit collected can be disposed in the following manner:
-In large treatment plant, grit is incinerated with sludge.
-In the past, grits along with screening was dumped into sea.
-Generally, grit should be washed before disposal to remove organic matter.
-Land disposal after washing is most common.

PROBLEM

Design a grit chamber for population 50000 with water consumption of 135 LPCD.

Solution:

Average quantity of sewage, considering sewage generation 80% of water supply, is
= 135 x 50000 x 0.8 = 5400 m3/day = 0.0625 m3/sec
Maximum flow = 2.5 x average flow
= 0.0625 x 2.5 = 0.156 m3/sec
Keeping the horizontal velocity as 0.2 m/sec (<0.228 m/sec) and detention time periodas one minute.
Length of the grit chamber = velocity x detention time
= 0.2 x 60 = 12.0 m

Volume of the grit chamber = Discharge x detention time

= 0.156 x 60 = 9.36 m3

Cross section area of flow 'A' = Volume / Length = 9.36/12 = 0.777 m2Provide width of the chamber = 1.0 m, hence depth = 0.777 m

Provide 25% additional length to accommodate inlet and outlet zones.Hence, the length of the grit chamber = 12 x 1.25 = 15.0 m

Provide 0.3 m free board and 0.25 m grit accumulation zone depth, hence total depth = 0.777 + 0.3 + 0.25 = 1.33 m and width = 1.0 m

5.4.1 STANDARDS OF EFFLUENT

SL. NO	PARAMETERS	STANDARDS			
		Inland surface water	Public sewers	Land of irrigation	Marine / coastal areas
1	Suspended solids mg/l, max.	100	600	200	a. For process waste water 100 b. For cooling water effluent 10 percent above total suspended matter of influent
2	Particle size of suspended solids	Shall pass 850 micron IS Sieve	-	-	a. Floatable solids, Solids max. 3 mm. b. Settleable solids. Max 856 microns
3	pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
4	Temperature	Shall not exceed 5^0C above the Receiving water temperature.	-	-	Shall not exceed 5^0C above the receiving water temperature.
5	Oil and grease, Mg / l max.	10	20	10	20

6	Total residual chlorine, mg/l max	1.0	-	-	1.0
7	Total nitrogen (as N); mg/l, max.	100	-	-	100
8	Biochemical oxygen demand (3 days at 27oC), mg/l, max.	30	350	100	100
9	Chemical oxygen demand, mg/l,	250	-	-	250
10	Mercury (As Hg), mg/l, max.	0.01	0.01	-	0.01
11	Copper (as Cu) mg/l, max.	3.0	3.0	-	30

5.4.2 SEWAGE DISPOSAL

SEWAGE DISPOSAL ON LAND:

Disposal of Sewage Effluents on land for irrigation in this method the sewage effluent (treated or diluted) is generally disposed of by applying it on land.

The percolating water may either soon the water table or is collected below by a system of under drains. This method can then be used for irrigating crops.

This method in addition to disposing of the sewage may help in increasing crop yields (by 33% or so) as the sewage generally contains a lot of fertilizing minerals and other elements.

However the sewage effluent before being used as irrigation water must be made safe. In order to lay down the limiting standards for sewage effluents, and the degree of treatment required, it is necessary to study as to what happens when sewage is applied on to the land as irrigation water.

The pretreatment process may be adopted by larger cities which can afford to conduct treatment of sewage when sewage is diluted with water or disposal for irrigation too large volumes of dilution water are generally not needed, so as not to require too large areas for disposal.

DISPOSAL BY DILUTION:

Disposal by dilution is the process whereby the treated sewage or the effluent from the sewage treatment plant is discharged into a river stream, or a large body of water, such as a lake or sea. The discharged sewage in due course of time, is purified by what is known as self purification process of natural waters. The degree and amount of treatment given to raw sewage before disposing it off into the river stream in question, will definitely depend not only upon the quality of raw sewage but also upon the self purification capacity of the river stream and the intended use of its water.
Dilution Factor:
The ratio of the quantity of the diluting water to that of the sewage is known as the Dilution Factor.

Conditions favouring Disposal by dilution:
The dilution methods for disposing of the sewage can favourably be adopted under the following conditions.

- When sewage is comparatively fresh (4 to 5 hr old) and free from floating and settleable solids. (or are easily removed by primary treatment)

- When the diluting water (is the source of disposal) has a high dissolved oxygen (0-0) content.
- Where diluting waters are not used for the purpose of navigation or water supply for at least some reasonable distance on the downstream from the point of sewage disposal.
- Where the flow currents of the diluting waters are favourable, causing no deposition, nuisance or destruction of aquatic life.

When the out fall sewer of the city or the treatment plant is situated near some natural water having large volumes.

DISPOSAL OF DIGESTED SLUDGE:

The digested sludge from the digestion tank contains a lot of water, and is therefore, first of all, dewatered or dried up before further disposal either by burning or dumping. Dewatering, drying and disposal of sludge by sludge drying beds:

Drying of the digested sludge on open beds of land is quite suitable for hot countries like India. Sludge drying beds are open beds of land, 4 5to 60 cm deep and consisting of about 30 to 45 cm thick graded layer of gravel or crushed stone varying in size from 15 cm at bottom t o 1.25 cm a t op, and overlain by 10 to 15 cm thick coarse sand layer.

The sewage sludge from the digestion tank is brought and spread over the top of the drying beds to a depth of about 20 to 30 cm. A portion of the moisture drains through the bed while most of it is evaporated to the atmosphere. It usually takes about two weeks to two months for drying the sludge, depending on the weather and condition of the bed.

Disposal of dewatered sludge:

The dewatered sludge obtained from mechanical devices in western countries is generally heat dried, so as to produce fertilizers. The wet sludge after mechanical dewatering is sometimes directly disposed of either in sea or in underground trenches or burnt.

Disposal by dumping into the sea:

The dewatered wet sludge may sometimes be discharged at sea from hopper barges or through outfall sewers. This method can, however be adopted only in case of cities situated on sea shores and where the direction of the normal winds are such as to take the discharged sludge in to the sea away from the shore line.

Disposal by burial in to the Trenches:

In this method, the digested sludge without dewatering is run in to trenches. When the sludge has dried to a firm state, it is covered a top with a thin layer of soil. After about a month, the land is ploughed up with powered lime and planted with crops.

Disposal by incineration:

The dewatered wet sludge produced in waste water treatment plant may also be disposed of by burning in suitably designed incinerators, when sufficient space is not available for its burial near the plant site or the sludge cannot be dried and used as manure.

MECHANISM OF AEROBIC AND ANAEROBIC SLUDGE DIGESTION WITH MERITS AND DEMERITS:

Sludge digestion is a biochemical phenomenon involving organisms, enzymes, food and environment. The principal objective of sludge digestion is to subject the organic matter present in the settled sludge of the primary and final sedimentation tanks to anaerobic or aerobic decomposition so as to make it amenable to dewatering on sand beds or mechanical filter before final disposal on land, lagoon or sea. Sludge digestion brings about reduction in volume. While anaerobic digestion of sludge produces gas which can be utilized wherever feasible, aerobic digestion does not produce any utilizable by product other than well stabilized sludge.

Anaerobic digestion is the biological decomposition of organic matter in absence of oxygen. It consists of two distinct stages

First stage (Acid fermentation)

Second stage (Methane fermentation)

Advantages

a. Lower BOD concentration in digester supernatant

b. Production of odourless and easily dewaterable biologically stable digested sludge.

c. Recovery of more basic fertilizer value in digested sludge.

d. Lower capital cost

e. Fewer operational problems

Disadvantages

a. Higher power costs generate higher operating costs comparable with anaerobic digestion

b. Gravity thickening process following aerobic digestion and to generate high solids concentration in the supernatant

c. Some aerobically digested sledges do not dewater easily in vacuum filtration

d. No methane gas is produced for recovery as a byproduct

ANAEROBIC SLUDGE DIGESTION:

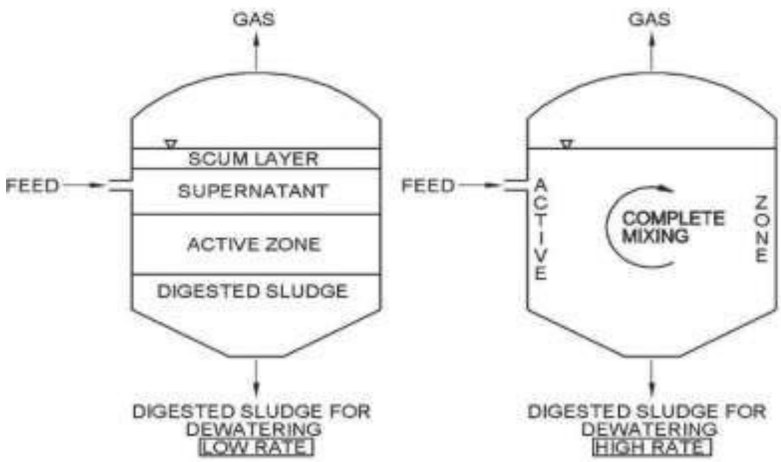
General:
This is the biological degradation of organic matter in the absence of oxygen. In this process, much of the organic matter is converted to methane, carbon-dioxide and water and therefore, it is a net energy producer. Since, little carbon and energy alone is available to sustain further biological activity, the remaining solids are rendered stable.

Microbiology of the Process:

Anaerobic digestion involves several successive biochemical reactions earned by a mixed culture of microorganisms. There are three degradation stages namely, hydrolysis, acid formation and methane formation.In the first stage of digestion, complex organic matter like proteins, cellulose, lipids are converted by extra cellular enzymes into simple soluble organic matter. In the second stage, soluble organic matter is converted by acetogenic bacteria into acetic acid, hydrogen, carbon dioxide and other low molecular weight organic acids. In the third stage, two groups of strictly anaerobic methanogenic bacteria, are active. While one group converts acetate into methane and bicarbonate, the other group converts hydrogen and carbon-dioxide into methane. For satisfactory performance of an anaerobic digester, the second and third stages of degradation should be in dynamic equilibrium, that is, the volatile organic acids should be converted into methane at the same rate as they are produced.

However, methanogenic microorganisms are inherently slow growing compared with the volatile acid formers and they are adversely affected by fluctuations in pH, concentration of substrates and temperature. Hence, the anaerobic process is essentially controlled by the methanogenic microorganisms.

Digestion Types:
Two different types in anaerobic sludge digestion processes are namely, low rate and high rate and are used in practice. The basic features are in Figure



Low Rate Digestion:

Raw sludge is fed into the digester intermittently. Bubbles of sewage gas are generated and their rise to the surface provides some mixing. In the case of few old digesters, screw pumps have been installed to provide additional intermittent mixing of the contents, say once in 8 hours for about an hour. As a result, the digester contents are allowed to stratify, thereby, forming four distinct layers: a floating layer of scum, layer of supernatant, layer of actively digesting sludge and a bottom layer of digested sludge; essentially the decomposition is restricted to the middle and bottom layers. Stabilized sludge that accumulates and thickens at the bottom of the tank is periodically drawn off from the centre of the floor. Supernatant is removed from the side of the digester and returned to the treatment plant.

High Rate Digestion:

The essential elements of high rate digestion are complete mixing and more or less uniform feeding of raw sludge. Pre-thickening of raw sludge and heating of the digester contents are optional features of a high rate digestion system. All these four features provide the best environmental conditions for the biological process and the net results are reduced digester volume requirement and increased process stability. Complete mixing of sludge in high rate digesters creates a homogeneous environment throughout the digester. It also quickly brings the raw sludge into contact with microorganisms and evenly distributes toxic substances, if any, present in the raw sludge. Furthermore, when stratification is prevented because of mixing, the entire digester is available for active decomposition, thereby increasing the effective solids retention time.

Pre-thickening of raw sludge before digestion results in the following benefits:

1. Large reduction in digester volume requirements
2. The thickener supernatant is of far better quality than digester supernatant; thereby, it has less adverse impact when returned to the STP
3. Less heating energy requirements
4. Less mixing energy requirements

NEED FOR SLUDGE DEWATERING AND EXPLAIN THE VARIOUS SLUDGE DEWATERING METHODS

Sludge dewatering:

Dewatering is a physical unit operation used to reduce the moisture content of the sludge and thus to increase the solids concentration.

Need for sludge dewatering:

1. Cost of trucking sludge to ultimate disposal site is reduced because of reduced sludge volume consequent to dewatering.

2. Ease in handling dewatered sludge.

3. Increase in calorific value of sludge by removal of moisture, prior to incineration.

4. Rendering the sludge totally odourless and non-putrisible.

5. Sludge dewatering is commonly required prior to land filling to reduce lechate production at landfill site.

Various methods:

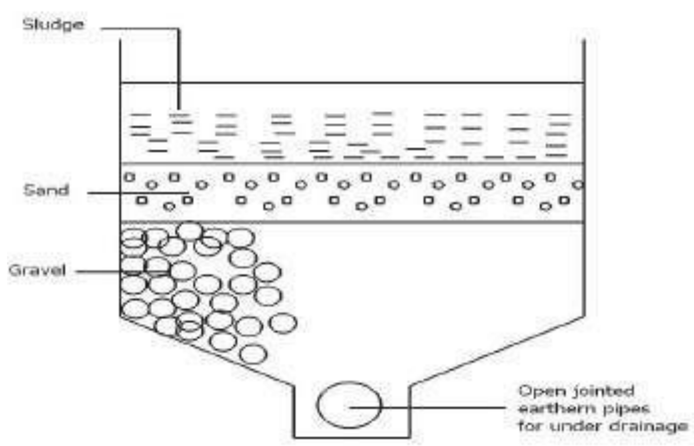
1. Sludge drying beds.

2. Mechanical methods.

3. Vacuum filters.

1. Sludge drying beds.

This method of dewatering and drying the sludge is especially suitable for those locations where temperature is higher,similar to the one prevailing in our country



A sludge drying bed usually consists of a bottom layer of gravel of uniform size over which is laid a bed of clean sand. Open jointed tile under drains are laid in the gravel layer to provide positive drainage as the liquid passes through the sand and gravel.

Under drains are made of vitrified clay pipes or tiles of at least 10cm diameter laid with open joint. Under drains are placed not more than 6m apart. Graded gravel is placed around the under drains in layers up to 30cm with a minimum of 15cm above the top of the under drains. At least 8cm of the top layer should consist of gravel of 3t o 6mm size.

Clean sand of effective size of 0. 5 to 0.75mm and uniform co-efficient not greater than 4.0 is placed over the gravel. The depth of sand may vary from 1 5t o 30cm. The drying beds are commonly 6t o 8m wide and 3 0t o 45m long. A length of 30m away from the inlet should not be exceeded with a single point of wet sludge discharge, when the bed slope is about 0.5% multiple discharge points should be used with large sludge beds to reduce the length of wet sludge travel. In order to have flexibility in operation, beds should be atleast two in number.

The area needed for dewatering the sludge is dependent on total volume of sludge, climate, temperature and location. Areas required for drying beds range from 0. 1t o 0.15m2/capita with dry solids loading of 60 to 120Kg/m2/year for digested mixed sludge. Sludge should be deposited evenly to a depth of not greater than 20cm.

When digested sludge is deposited on a well drained bed of sand described above, the dissolved gases tend to buoy up float the solids leaving a clear liquid at the bottom which drains off in a few hours after which drying commences by evaporation. The sludge cake shrinks producing cracks which accelerates evaporation from the sludge surface. With good drying conditions t, he sludge will dewater satisfactorily and become fit for removal in about 2t o 3 weeks producing a volume reduction of 20 to 40%.driedsludge can be removed by shovel or forks when the moisture content is less than 70%.when the moisture content reaches 40%, the cake becomes lighter and suitable for grinding wheel barrows or pickup trucks are used for hauling of sludge cakes.

2. Mechanical methods.

Vacuum filtration is the most common mechanical method of dewatering, filter presses and centrifugation being the other methods. Chemical conditioning is normally required prior to the mechanical methods of dewatering.

Mechanical methods may be used to dewater raw or digested sludge’s preparatory to heat treatment by vacuum filtration because the coarse solids are rendered fine during digestion. Hence filtration of draw primary or a mixture of primary and secondary sludge’s permits slightly better yields, lower chemical requirements and lower cake moisture contents than filtration of digested sludge’s.

When the ratio of secondary and primary sludge increase, it become more and more difficult to dewater the filter. The feed solids concentration would demand unduly large filter surface I. n t his method, conditioned sludge is spread out in a thin layer on t he filtering medium, the water portion being separated due to the vacuum and the moisture content is reduced quickly.

3. Vacuum filters:

Vacuum filters consists of a cylindrical drum over which is laid a filtering medium of wool, cloth or felt, synthetic fiber or plastic or stainless steel mesh or coil springs. The drum is suspended horizontally so that one quarter of its diameter is submerged in a tank containing sludge. The valves and piping's are arranged to apply a vacuum on the inner side of the filter medium as the drum rotates slowly in the sludge. The vacuum holds the sludge against the drum as it continues to be applied as the drum rotates out of the sludge tank. This pulls water away from the sludge leaving a moist cake mat at the outer surface. The sludge cake on the filter medium is scraped from the drum just before it enters the sludge tank again. The filtration rate is expressed in kg of dry solids per square meter of medium per hour. It varies from 10kg/m2/h for activated sludge alone to 50kg/m2/hr f \or primary sludge's.

SLUDGE THICKENING:

This is to thicken the concentration of sludge solids generated in the clarifier to make sludge digestion and sludge dewatering more effective. Sludge to be thickened may be primary sludge or combined sludge from primary and excess sludge. Thickening may be broadly classified into three types namely, gravity, centrifugal and floatation. The floatation can further be dissolved-air floatation or dispersed-air floatation. When the thickening of sludge is inadequate, the filtrate from dewatering will have large amounts of suspended solids returning to the STP and affect the water quality.

Hence, excess sludge is increasingly being mechanically thickened using centrifugal thickening machines or floatation thickeners. Moreover, when performing sludge treatment for sludge collected from various STPs, sludge with varying properties is likely to be treated; therefore, forced sludge thickening process such as by using mechanical thickening equipment is indispensable. De gritting and debris removal equipment preferably be installed as the pre-treatment process before thickening unless the STP itself has such facilities in the raw sewage stage.

Gravity Thickening:

Gravity thickening is the most common practice for concentrating the sludge. It is adopted for primary sludge or combined primary and activated sludge, but is not successful in dealing with excess sludge independently. Gravity thickening of combined sludge is not effective when excess activated sludge exceeds 40% of the total sludge weight. In such cases, other methods of thickening of the excess activated sludge have to be considered.

Gravity thickeners are either continuous flow or fill and draw type, with or without addition of chemicals. Use of slowly revolving stirrers improves the efficiency. Continuous flow tanks are deep circular tanks with central feed and overflow at the periphery. They are designed for a hydraulic loading of 20,000 to 25,000 lpd/m2. Loading rates less than 12.000 lpd/m2 are likely to give too much solids to permit this loading hence, it is necessary to dilute the sludge with plant effluent and it is referred to as dilution water. Better efficiencies can be obtained for gassy sludge by slow revolving stirrers.

Air Floatation Thickening:

Air floatation units employ floatation of sludge by air under pressure or vacuum and are normally used for thickening the waste activated sludge. These units involve additional equipment, higher operating costs, higher power requirements, and more skilled maintenance and operation. However, the removal of oil and grease, solids, grit and other material as also odour control are distinct advantages.

In the pressure type floatation units, a portion of the subnatant is pressurized from 3 to 5 kg/cm2 and then saturated with air in a pressurization chamber. The effluent from this is mixed with influent sludge immediately before it is released into the flotation tank. Excess dissolved air then rises up in the form of bubbles at atmospheric pressure attaching themselves to particles which form the sludge blanket. Thickened blanket is skimmed off while the un-recycled subnatant is returned to the plant.

The vacuum type employs the addition of air to saturation and applying vacuum to the unit to release the air bubbles which float the solids to the surface. The efficiency of air floatation units is increased by the addition of chemicals like alum and polyelectrolytes. The addition of polyelectrolytes does not increase the solids concentration, but improves the solids recovery rate from 90% to 98%.

Centrifugal Thickening:

Thickening by centrifugation is applied only when there is space limitation or sludge characteristics will not permit the adoption of the other two methods. This method involves high maintenance and power costs. Centrifuges employed are of either disc or solid bowl type. Disc centrifuges are prone to clogging while the latter gives a lower quality of effluent.

Sludge Feed Pump:
Decide the sludge feed pump after considering the following:

1. Select a pump with adequate capacity.
2. Install separate pumps for each centrifugal thickener.

Appurtenances:

Decide the appurtenances after considering the following:

1. If necessary, install de-gritting and debris removal equipment before thickening.
2. Install sludge feed tank.
3. Install thickened sludge storage tank.
4. Install water supply system for internal cleaning of the centrifugal thickener and for cooling the bearing.
5. Install equipment for controlling the water content of thickened sludge.
6. If necessary, install chemical dosing equipment.

SEWAGE SICKNESS:

When sewage is applied continuously, once the Piece of land, the soil pores or void may get filled up and clogged with sewage matter retained in them. The time taken for such a clogging will, of course depend upon the type and the load prevent in sewage. But when once these voids are clogged, free circulation for air will be prevented and anaerobic conditions will develop on the pores. Due to this the aerobic decompositionof organic matter will stop, and anaerobic decomposition will start. The organic matter will there, of course, be minor load but with the evolution of foul gases like H_2S, CO_2, CH_4. This phenomenon of soil getting clogged is known as sewage sickness of land

Preventive measure in adopted for sewage sickness

1. Primary treatment of sewage
2. Choice of land
3. Under-drainage of soil.
4. Giving rest to the land.
5. Rotation of crops
6. Applying shallow depths.

SEWAGE FARMING:

When sewage is applied on agricultural land for the growth of crops, then it is termed as sewage farming. The sewage contains much fertilizing elements such as nitrates,sulphates and phosphates.These elements are extracted from the soil by the roots of the plants.

Conditions of sewage farming:

The following conditions should be remembered while providing the method of sewage farming

a. The farm should be located far away from the locality, because it may create bad smell and insanitary condition.
b. The raw sewage should never be supplied to the farm.
c. It is better to apply the sewage after primary treatment.
d. Precautions should be taken to avoid sewage sickness.

Sewage is discharged on vacant land which is provided underneath with a system of properly laid under drains. These under drains basically consist of 15 to 20 cm river process tile pipes, load open founded at a spacing of 12 to 30 m. The effluent collected in these drains after getting filtered through the pores is a generally small (as a large quantity gets evaporated) and well stabilized, and can be early disposal into some natural water courses, without any further treatment.

In case of sewage farming, however the trees are load upon the use of sewage efficient for irrigation crops and increasing the fertility of the soil. The pre-treatment of sewage in removing the ingredients which may prove harmful and toxic to the plant is therefore, necessary in this case.

Application of sewage:

The sewage may be applied on the land by the following methods

1. Surface irrigation system
2. Sub-surface irrigation system
3. Sprinkler irrigation system

1. Surface irrigation system

This system may be of following types

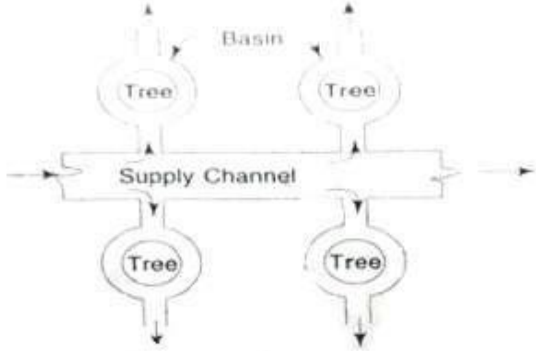
a) Basin method

b) Furrow method

c) Flooding method

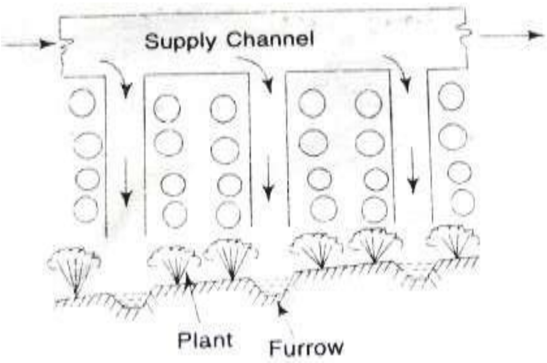
a) Basin method

In this method, each tree or group of trees are enclosed by circular channel through which sewage flows. This circular channel is known as basin. The basins are connected to the supply channel. When the basins are filled up, the supply is cut-off.



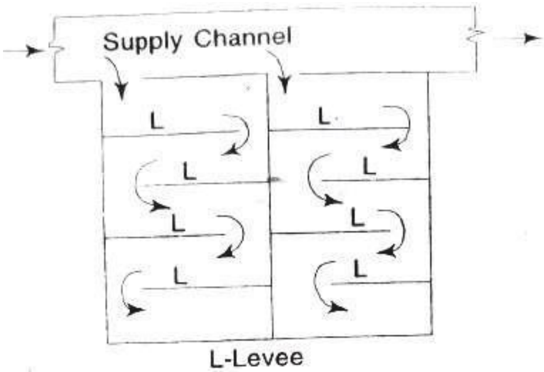
b) Furrow method

In this method, the sewage is supplied to the land through narrow channels, which are known as furrows. This method is suitable for the crops which are sown in rows. The crops are potato, ground nut, sugar cane, etc.



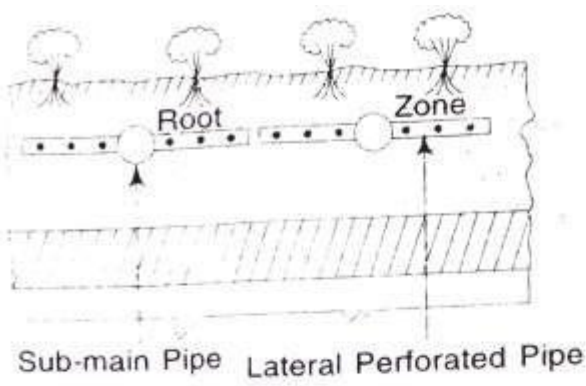
c) Flooding method

In this method, agricultural land is divided into small plots by levees (i.e. low bunds). The sewage is supplied to the plots through the supply channel. The sewage covers the entire area by flowing in Zigzag way.



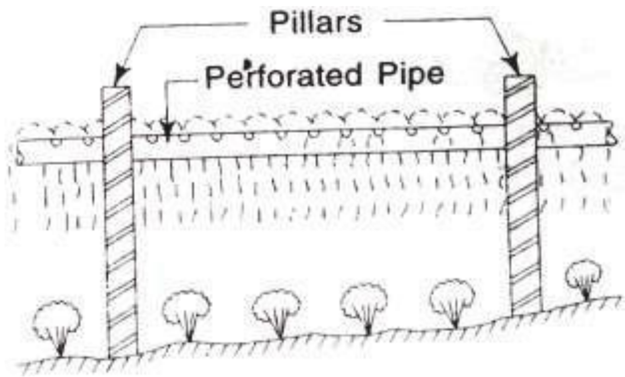
2. Sub-surface irrigation system

In this method, sewage is applied to root zone of crops by underground network of pipes. It consists of lateral perforated pipes which are connected to sub-main pipe line. The perforated pipe allows the sewage to drip out slowly and the soil below the root zone absorbs the sewage continuously.



3. Sprinkler irrigation system

In this method, sewage is applied to the land in the form of spray. The system is achieved by the network of main pipes and lateral pipes are perforated through which the sewage comes out.



STAGES IN THE SLUDGE DIGESTION PROCESS:

Three distinct stages have been found to occur in the biological action involved in the natural process of sludge digestion. The stages are

1. Acid fermentation
2. Acid regression
3. Alkaline fermentation

1. Acid fermentation stage or acid production stage:

In this first stage of sludge digestion, the fresh sewage-sludge begins to be acted upon by anaerobic and facultative bacteria called acid formers. These organisms solubilize the organic solids through hydrolysis. The soluble products are then fermented to volatile acids and organic alcohols of low molecular weight like propionic acid, acetic acid, etc. Gases' like methane, CO2, and H2S are also evolved. Intensive acid production makes the sludge highly acidic, and lowers the pH, value to less than 6.Highly putrefaction odours are evolved during this stage, which continues for about 15 days or so(at about 21°C). BOD of the sludge increases to some extent, during this stage.

2. Acid regression stage:

In this intermediate stage, the volatile organic acids and nitrogeneous compounds of the first stage are attacked by the bacteria, so as to form acid carbonates and ammonia compounds, small amount of H2S and CO2 gases are also given off. The decomposed sludge has a very offensive odour and its pH value rises a little, and to be about 6.8, the decomposed sludge also entraps the gases of decomposition, becomes foamy and rises to the surface form scum. This sludge continues for a period of about 3 months or so. BOD of the sludge remains high even during this stage.

3. Alkaline fermentation stage:

In this final stage of sludge digestion more resistant materials like proteins and organic acids are attacked at broken up by anaerobic bacteria, called methane formers, into simple substances like ammonia, organic acids and gases. During this stage, the liquid separates out from the solids, and the digested sludge is formed. This sludge is granular and stable, and does not give offensive odours (. It has a musty earthy odour). This digested sludge is collected at the bottom of the digestion tank and is also called ripened stage. Digested sludge is alkaline in nature. The pH value during this stage rises to a little above 7, in n the alkaline range. Large volumes of methane gas (having a considerable fuel value) along with small amount of CO_2 and nitrogen are evolved during this stage. This stage extends for a period of about one month or so. The BOD

of the sludge also rapidly falls down during this stage. It is thus, seen that several months (about 4.5 months or so)are required for the complete process of digestion to take place under natural uncontrolled conditions at about 21°C. This period of digestionis however very much dependent upon the temperature of digestion and other factors.