UNIT-1

ENVIRONMENT

The term environment is defined as all the systems namely atmosphere, lithosphere, hydrosphere (non living components) and biosphere (living components) surroundings us. It includes air, water, food, the pollutions, waste materials and other ecological problems, which effect the life and health of human beings and other life.

Environmental engineering is concerned with the control of all those which exercise or may exercise deleterious effect on his development, health and sundial with the consideration of the physical, economic and social impact of the control measures applied. Environmental engineering deals with the application of engineering principles to the control, modification and adaption of the physical, chemical and biological factors of the environment in the interest of man's health, comfort and social wellbeing. In this textbook, some aspects of environmental engineering, such as ecology, water supply systems, waste water treatment and disposal, rural sanitation and air pollution are presented.

If proper arrangements for the collection, treatment and disposal of all the wastes produced from the town or city such as water from bathroom, kitchens, lavatory basins, house and street washings, from various industrial processes semi liquid wastes of human and animal excreta, dry refuse of house and street sweepings, broken furniture, crockery, wastes from Industries etc are not made, they will go on accumulating and create

(i) Buildings and roads will be in danger due to accumulation of spent water in their foundation
(ii) Disease causing bacteria will bread up in the stagnate water
(iii) Drinking water will be polluted.
Total insanitary conditions will be developed in the town or city and it will become impossible for the public to live in the town or city. Therefore in the interest of the community of the town or city it is most essential to collect, treat and dispose of all the waste products of city in such a way that it may not cause any problem to the people residing in the town. Table 1.1. illustrates waste products of town or city (outlines of sanitary engineering).

OBJECT OF PROVIDING SEWERAGE WORKS:

The following are the aims and objects of sewage disposal.
1. Proper disposal of human excreta to a safe place, before its starts decomposition and may cause insanitary conditions in the locality
2. To take out all kinds of wastewater from the locality immediately after its use, so that mosquitos, files, bacteria etc may not breed in it and cause nuisance.
3. Final disposal of sewage on land or in near by watercourses after some treatment so that receiving land or water may not get polluted and unsafe for its further use.
4. As far as possible the fertilizing elements of sewage may be used in growing crops through farming and getting some income in addition to the disposal of sewage
5. In unsewered areas, the treatment of sewage from individual houses, should be done by septic tank or other suitable means and the effluent should be disposed of.

6. If the sewage is disposed of on land, it should have such s degree of treatment that it may not affect the sub-soil in anyway.

DEFINITIONS OF TERMS-SULLAGE, SEWAGE, SEWER AND SEWERAGE:

Sullage: The liquid waste from latrines, Urinals stable etc is known as sullage.

Sewage: The term sewage is used to indicate the liquid waste from the community and it includes sullage, discharge from latrines, urinals, stable etc industrial waste and storm water.

Sewer: The underground conducts or drains through which is conveyed are known as the sewers.

Sewerage: The entire science of collecting and carrying sewage by water carriage system through sewers is known as sewerage.

Garbage: The term indicates dry refuse which includes decayed fruits, grass, leaves, paper pieces, sweepings, vegetables etc.

Refuse: The term refuse is used to indicate all kinds of dry wastes of the community (i.e.,) street and house sweepings, garbage etc.

CLASSIFICATION OF SEWAGE:

1. Storm Sewage: Which includes surface runoff developed during and immediately after rainfall over the concerned area.

2. Sanitary Sewage: Which includes the liquid wastes of domestic and industrial places. This sewage is extremely foul in nature and required to be disposed of very carefully.

SYSTEMS OF SEWERAGE METHODS:

1. CONSERVANCY SYSTEM:

In this system various types of refuse and storm water are collected, conveyed and disposed off separately by different methods in this system. This method is also called dry system and is in practice from very ancient times. This is method is adopting in small towns, villages and undeveloped portions of large city even it is out of date system.

In this method garbage or dry refuse is collected from the dustbins and conveyed by trucks or covered carts once or twice in a day. All the uncombustible portions such as sand, dust, clay, ashes etc are used for filling low lying areas and combustible portions such as dry leaves, waste paper, broken furniture etc... are burnt. The decaying fruits, vegetables, grass are first dried and then disposed of by burning or in the manufacture of manure. Human excreta or night soil is collected in separate liquid and semi-liquid wastes by animal drawn carts, trucks or tractor trailors and buried in trenches. After 2-3 years the buried night soil is converted into an excellent manure which can be used for growing crops. In this system sullage and storm water are also carried separately in closed or open drains upto the point of disposal, where they are allowed to mix up with streams, rivers or sea.

ADVANTAGES AND DISADVANTAGES:

ADVANTAGES:

1. Initial cost is low, because storm water can pass through open drains.
2. The quantity of sewage reaching at the treatment plant before disposal is low.
3. The sewer section is small and no deposit of silting because storm water goes in open drains

DISADVANTAGES:

1. Possibility of storm water may mix with sewers causing heavy load on treatment plant.
2. In crowded lanes it is difficult lay two sewers or construct drains roadside causing great inconvenience to the traffic.
3. More land is required for human excreta.
4. Liquid refuse may get on access in the sub soil and pollute the underground water.
5. Aesthetic appearance of city cannot be increased.
6. Decomposition of sewage causes insanitary conditions which are dangerous to the public health.
7. This system is completely depends upon the mercy of sweepers at every time and may possibility of spreading of diseases in the town if they are on strike.

2. WATER CARRIAGE SYSTEM:

In this system, the excremental matters are mixed up in the large quantity of water and are taken out from the city through properly designed sewerage systems where they are disposed off after necessary treatment in a satisfactory manner. The sewage so formed in water carriage system consists of 99.9 percentage of water and 0.1 percentage of solid matters. All the solid matters remain in suspension in the sewage and donot change the specific gravity of water. So all the hydraulic formulae can be directly used in the design of sewerage system and treatment plants. This system is universally used nowadays because of the following advantages.

MERITS AND DEMERITS OF WATER CARRIAGE SYSTEM:

The following are the merits of water carriage system.

1. It is hygienic method because all the excremental matters are collected and conveyed by water only.
2. There is no nuisance in the streets of town and risk of epidemics reduced because of underground sewerage system.
3. Less space is occupied in crowded lane as only one sewer is laid
4. Self cleaning velocity can be obtained even at less gradients due to more quantity of sewage.
5. The land required for the disposal work is less as compared to conservancy system.
6. This system doesnot depend on manual labour at every time except when sewers get choked.
7. The usual water supply is sufficient and no additional water is required in water carriage system.
8. Sewer after proper treatment can be used fro various purposes.

DEMERITS

The main disadvantage of this system is the wastage of water (99.9% of water).

1. This system is very costly in initial cost.
2. The maintenance of this system is also costly.
3. During monsoon large volume of sewage is to be treated compared to remaining period of year.

COMPARISION OF CONSERVANCY AND WATER-CARRIAGE SYSTEMS:

CONSERVANCY SYSTEM	WATER-CARRIAGE SYSTEM
1. Very cheap in initial Cost	1. It involves high initial cost
2. Due to foul smell from latrines, they are to be constructed away from the living room	2. As there is no foul smell, latrines remain clean and neat and hence are constructed with room.
3. The aesthetic appearance of the city cannot be increased	3. Good aesthetic appearance of the city can be obtained.
4. Storm water is carried in usually surface drains, hence no problem of pumping the storm water	4. Sewage is treated before disposing of ,it may or may not require pumping it depends on the topography of the town.
5. The quantity of waste liquid reaching the disposed point is less, hence it can be disposed of without any treatment.	5. Large quantity of sewage highly polluted in nature, it requires its treatment before disposal so it is costly process.
6. This system is fully dependent on the human agency	6. This system is not dependent on the human agency
7. As sewage is disposed of without any treatment it may pollute the natural water courses	7. Sewage is treated upto required degree of sanitation.
8. For burying of excremental matter, large area is required.	8. Less area is required as compared to conservancy system.

TYPES OF SEWERAGE SYSTEM AND THEIR SUITABILITY:

The sewerage system are classified as follows:

(a) Combined system
(b) Separate system
(c) Partially separate system

(a) COMBINED SYSTEM:

This system is best suited in areas having small rainfall, which is distributed, throughout the area, because at such places self-cleaning velocity will be available in every season. As only one sewer is laid in this system, it is best suited for crowded area because of traffic problems. The combined system can also be used in area having less sewage, to obtain the self-cleaning velocity.

MERITS AND DEMERITS OF COMBINED SYSTEM:

The following are the merits of combined system

1. There is no need of flushing because self-cleaning velocity is available at every place due to more quantity of sewage.
2. The sewage can be treated easily and economically because rainwater dilutes the sewage.
3. House plumbing can be done easily only one set of pipes will be required.

DEMERITS:

The following are the demerits of the combined system 1. The initial cost is high as compared to seperate system

2. It is not suitable for areas having rainfall for smaller period of year because resulting in the silting up of the sewers due to self velocity is not available
3. During heavy rainfall, the overflowing of sewers will endanger the public health
4. If whole sewage is to be disposed of by pumping, it is uneconomical

(b) SEPERATE SYSTEM:

When domestic and industrial sewage are taken in oneset of sewers, where as storm and surface water are taken in another set of sewers, it is called seperate system.

MERITS AND DEMERITS OF COMBINED SYSTEM:

The following are the merits of the seperate system

1. Since the sewage flows in seperate sewer, the quantity to be treated is small which results in economical design of treatment works.
2. Separate system is cheaper than combined system, because only sanitary sewage flows in closed sewer and storm water which is unfoul in nature can be taken through open channel or drains, whereas both types of sewage is to be carried in closed sewer in combined system
3. During disposal if the sewage is to be pumped, the separate system is cheaper
4. There is no fear of steam pollution.

DEMERITS:

1. Flushing is required at various points because self-cleaning velocity is not available due to less quantity of sewage
2. There is always risk that the storm water may enter the sanitary sewage sewer and cause over-flowing of sewer and heavy load in the treatment plant
3. Maintenance cost is more because of two sewers
4. In busy lanes laying of two sewers is difficult which also causes great inconvenience to the traffic during repairs

(C) PARTIALLY SEPERATE SYSTEM:

In the seperate system, if a portion of storm water is allowed to enter in the sewers carrying sewage and the remaining storm water flows in seperate set of sewers, it is called partially seperate system

MERITS AND DEMERITS OF PARTIALLY SEPERATE SYSTEM:

MERITS:

1. It is economical and reasonable size sewers are required because as it is an improvement over seperate system.
2. The work of house-plumbing is reduced because the rain water from roof, sullage from bath and kitchen, can be taken in the same pipe carrying the discharge from the water closets.The water from all other places can be taken in seperate sewer or drain.
3. No flushing is required because small portion of storm water is allowed to enter in sanitary sewage.

DEMERITS:

1. Cost of pumping is more than seperate system when pumping is required because portion of storm water is mixed.
2. There are possibilities of over-flow.
3. In dry weather, the self cleaning velocity may not develop.

QUANTITY OF SEWAGE

In order to find out suitable section of sewer, it is necessary to determine the quantity of sewage that will flow through the sewer. The sewage consists of dry weather flow and storm water.

QUANTITY OF DISCHARGE IN SEWERS:

The quantity of discharge in sewers is mainly affected by the following factors.

(i) Rate of water supply
(ii) Population
(iii) Type of area served as residential, industrial or commercial
(iv) Ground water infiltration

(i) RATE OF WATER SUPPLY:

The rate of sewage may be 60 to 70 percent of water supply due to various reasons such as consumption, evaporation, use in industries etc. This may be changes daily, seasonal and also standard of living of people.

(ii) POPULATION:

As the population increases the quantity of sewage also increases because the consumption of water is more.

(iii) TYPE OF AREA SERVED:

The quantity of sewage depends upon the type of area as residential, industrial or commercial. The quantity is depends on population if it is residential, type of industry if it is industrial

Commercial and public places can be determined by studying the developing of other such places.

(iv) GROUND WATER INFILTRATION:

When sewers laid below the water table in the ground, the ground water may percolate in the sewer from the faulty joints and cracks in the pipelines. The quantity of infiltration water in the sewer depends upon the height of the water table about the sewer invert, permeability of soil, size and nature of the faults or cracks in the sewer line. As per the U.S.A. reports

(i) 4.5 to 45 cum/hectare area/day

(ii) 11 to 225 cum/hectare area/km length of the sewer line

(iii) 0.7 to 7.2 cum/day/cm of dia of the sewer.

DRY WEATHER FLOW:

The sanitary sewage, which includes wastewater from residences and industries, is known as Dry Weather Flow (D.W.F)

VARIABILITY OF FLOW:

Practically the average sewage never flows in the sewer, it continuously varies from hour to hour of the day and season to season. The consumption of water in summer is more than in winter or rainy season and this change in consumption of water directly affects the quantity of sewage. Practically it has been seen that the maximum to average flow of sewage is between 1.5 to 1.0 and average to minimum is between 1.2 to 1.0

DETERMINATION OF STORM WATER FLOW:

The quantity of storm water, which is known as the wet weather flow (W.W.F), that will enter the sewer is to be carefully determined. The following are the factors mainly affect the quantity of storm sewage.

(i) Intensity of rainfall

(ii) Characteristics of catchment area

(iii) Duration of storm

(iv) Atmospheric temperature, wind and humidity

Generally two methods are used to calculate the quantity of storm water.

(i) Rational method

(ii) Empirical formulae method

(i) RATIONAL METHOD:

In this method , the storm water quantity is determined by the rational formula

$Q = C.I.A/360$ where Q=quantity of storm water in m^3/sec

C=Coefficient of runoff from table

I=intensity of rainfall in mm/hour

A=drainage area in hectares

* The runoff coefficient 'C' is calculated (overall)

$A1C1 + A2C2 + ---------+ AnCn$

$$= \frac{\sum AC}{A1 + A2 + \text{----------} + An} = \sum AC \; / \; \sum A$$

Where A1, A2, A3 ------- An are the different types of areas
And C1, C2, C3 ------- Cn are their runoff coeff. respectively from table.

(ii) EMPIRICAL FORMULAE METHOD:

For determining runoff from very large areas under specific conditions such as slope of land, imperviousness, rate of rainfall etc. These formulae are derived after long practical experience and collection of field data.

(A) Burkli – Zeighar formula (used in switzerland)

$$Q = \frac{C.I.A \; \sqrt[4]{S}}{141.58 \; A}$$

(B) Mc.Math Formula (used in U.S.A)

$$Q = \frac{C.i.A \; \sqrt[5]{S}}{148.35 \; A}$$

(C) Fuller's Formula

$$Q = \frac{C.M^{0.8}}{13.23}$$

(D) Funnig's Formula

$$Q = 12.8 \; M^{5/8}$$

(E) Tallbot's Formula

$$Q = 22.4 \; M^{1/4}$$

Where Q = runoff in cum/sec
C = runoff coefficient
i = intensity of rainfall in cm/hour
S = slope of the area in metre per thousand metre
A = drainage area in hectare
M = drainage area in square km

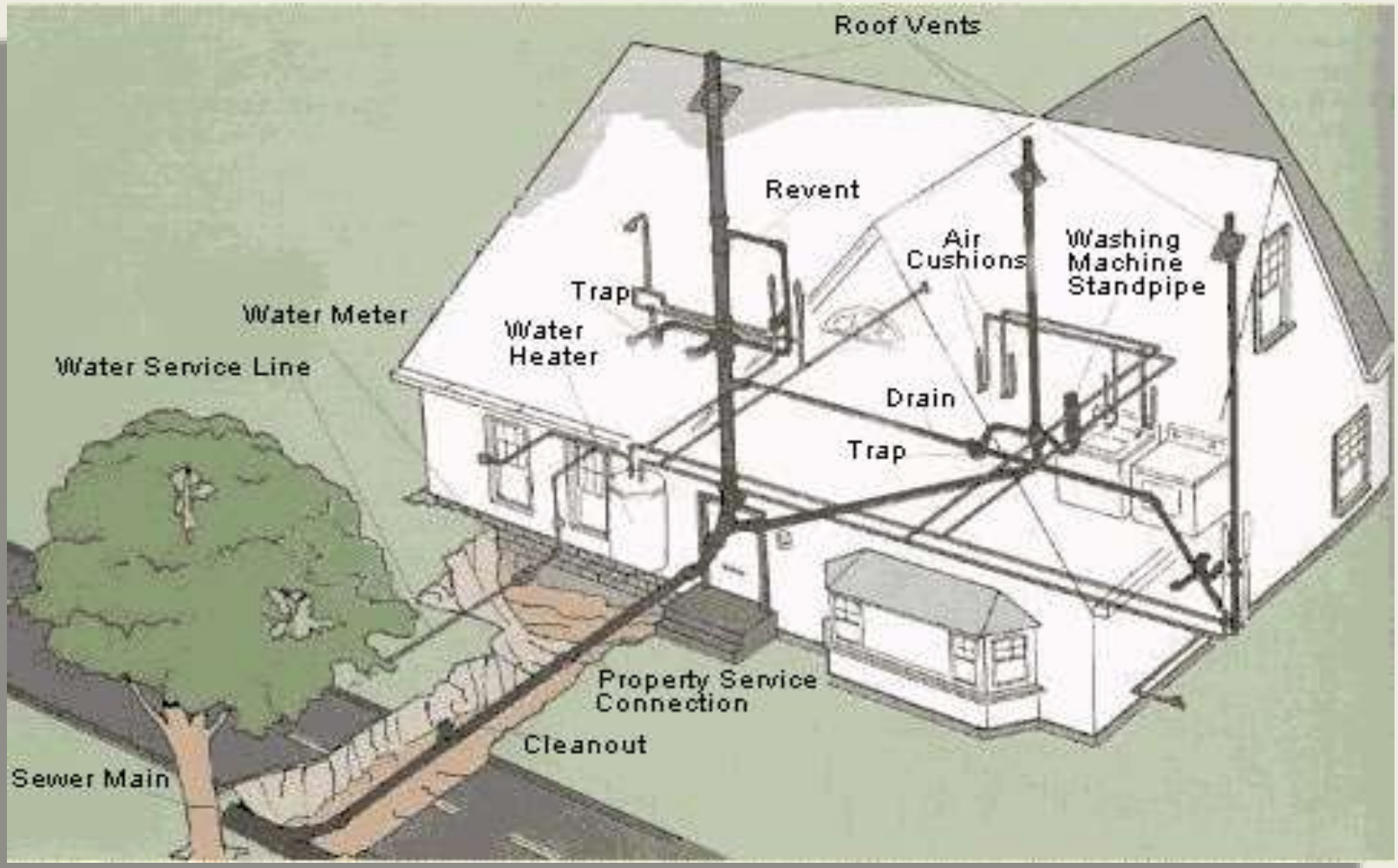
House Drainage System

Building Utility & Services

House Drainage System

The W.C, Bathrooms, Sinks, Wash basins, etc. are important components of a house. The occupants of the house make use of the above components and as a result of that there is a formation of waste water. **The Waste water from W.C, bathrooms, sinks and wash basins is to be properly disposed in to the muncipal sewers**. It is therefore necessary to construct a system of conveyance of wastewater from W.C, bathrooms, **kitchens and washbasins and disposal to the muncipal sewer. This system is known as house drainage system**

House Drainage System



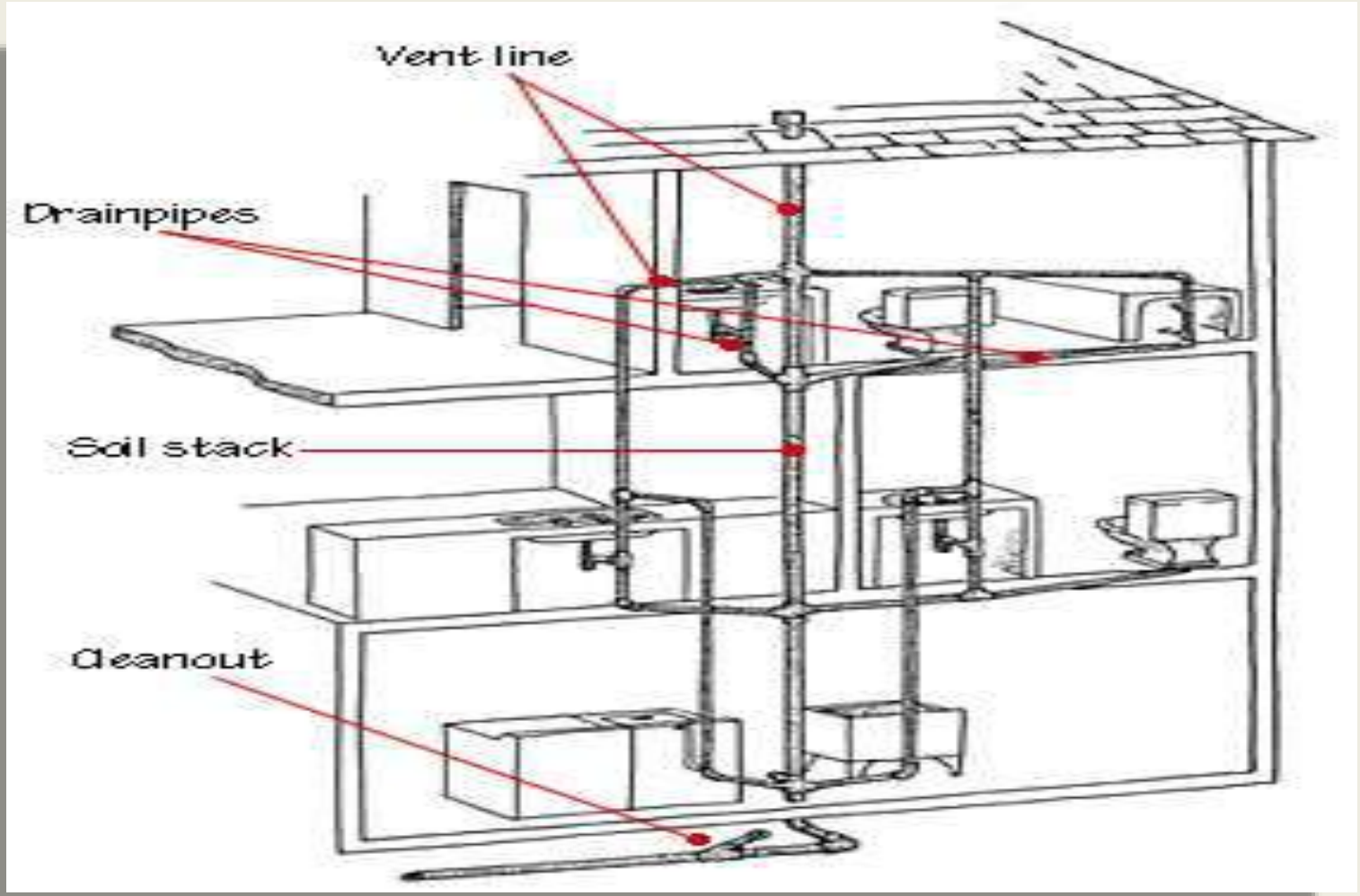
Definition of Terms

- Before studying the principles for design and construction of house drainage system it is necessary to first understand the basic terms used in subsequent description of topics in this chapter. Important terms are defined as follows:
- **Wastewater**: Water when used for different purpose like domestic commercial, industrial etc., receives impurities and become wastewater. Thus wastewater is used water and it has **physical, chemical, and biological** Impurities in it, wastewater is a general term.
- **Sewage:** The waste water coming from W.C. and containing human excreta is known as sewage.

Definition of Terms

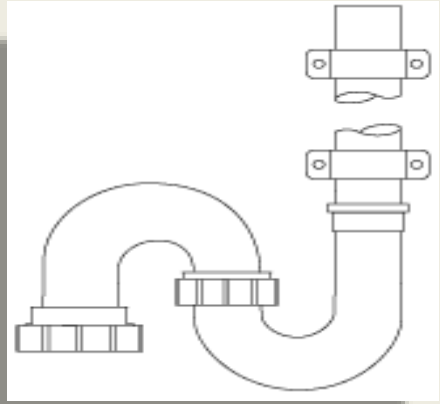
- **Sullage:** The Wastewater coming from bathrooms and kitchens which does not contain fecal matter is known as sullage.
- **Plumbing System:** It is entire system of pipe line for providing water supply to the building or it is a system of pipes for disposal of wastewater from the building.
- **Sewer:** A pipe carrying sewage/ wastewater is called sewer.
- **Soil Pipe**: It is pipe carrying sewage from W.C.
- **Waste Pipe:** It is a pipe carrying sulluge from bathrooms, kitchens, sinks, wash basins, etc.
- **Sewerage System:** A system of sewers of different types and sizes in a town collecting wastewater from the town and carrying it to the wastewater treatment plant.

Plumbing systems



Definition of Terms

- **Manhole:** These are RCC/ Masonary chambers constructed at suitable intervals along sewer lines.
- **Traps:** Traps are defined as fittings at the end of soil pipes of waste pipes to prevent foul gases coming out of the soil pipe/ waste pipe.



Principles Of House Drainage

- House Drainage should be **preferable laid by side of the building** to facilitate easy repair and better maintenance.
- House sewer joints should be **leek proof** because leekage if any shall create an odour problem and leaked wastewater shall infilterate in the ground and shall reduce **bearing capacity of soil** below foundation, which is not desirable.
- The sewage or sullage should **flow under the force of gravity**.
- The house sewer should **always be straight**.
- The entire system should be **well ventilated** from start to the end.
- The house sewer should be connected to the manhole such that the invert level is sufficiently higher to avoid back flow of sewage in house sewer.
- Where ever there is change in direction of sewer line in the premises, provide **inspection chamber at the junction**.
- **Rain water** from roofs or open courtyards **should not be** allowed to flow through the **house sewers**.
- **Siponage action** can never be permitted and therefore adequate **ventilation systems** should be installed.

Traps And Pipes and other components of house Drainage System

- Following are the main components of house drainage system
- Traps
- Pipes
- Sanitary Fittings

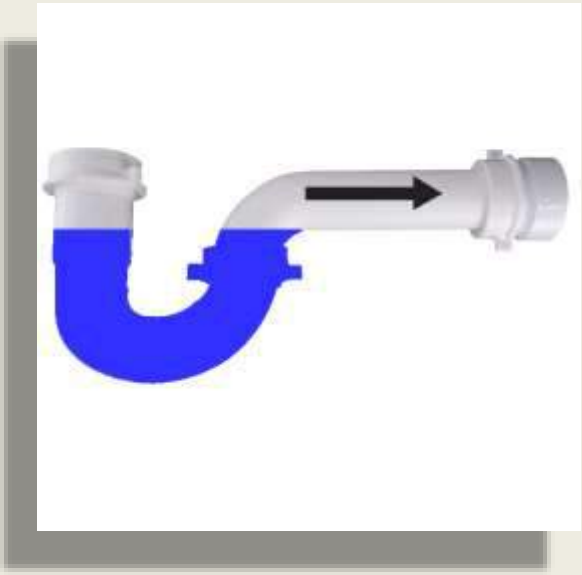
Traps And Pipes and other components of house Drainage System

- Following are the main components of House drainage system.
- **Traps:** Good Traps should have following Qualities:
- ***Should provide enough water seal (around 50 mm) with large surface area.***
- ***Interiors surface should be smooth so that the flow is not obstructed which enables self cleansing.***
- ***An assess door should be provided for cleaning the trap.***
- ***It should be made of non- adsorbent material***.

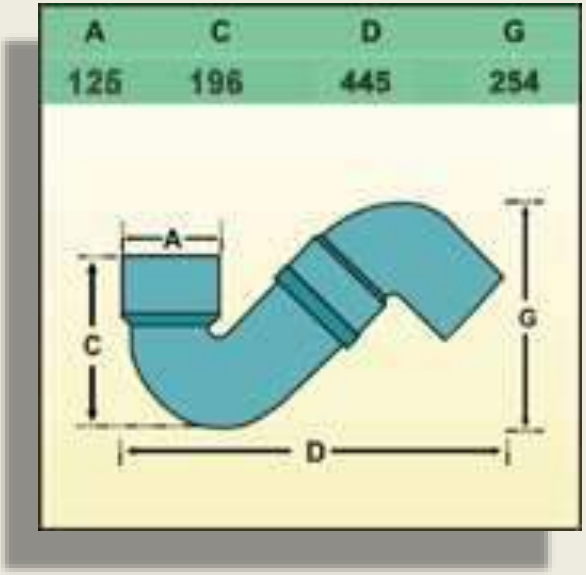
Classification of Traps

- Depending upon the shapes the traps are classified as:
- **P-Trap**
- **Q-Trap**
- **S-Trap**
- Above three types of traps are shown in the following figures.

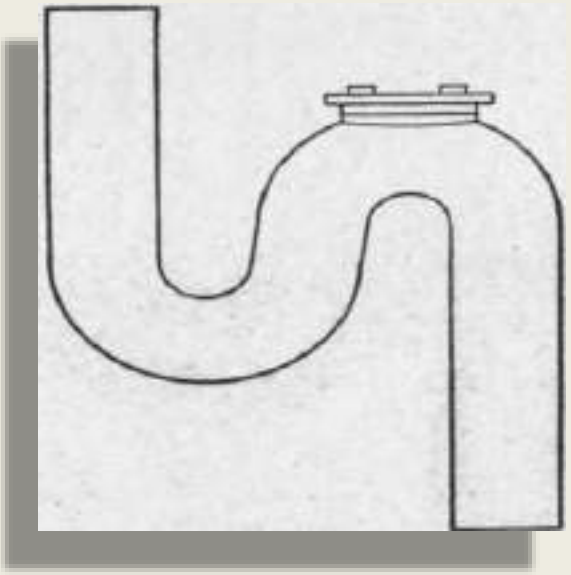
P, Q and S Traps



P Trap



Q Trap



S Trap

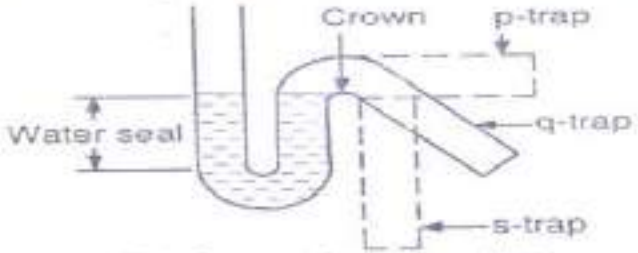
P, Q and S Traps

Classification of Traps

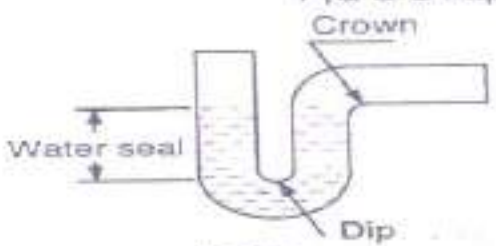
Depending upon the shapes the traps are classified as :

(i) P-trap (ii) Q-trap (iii) S-trap

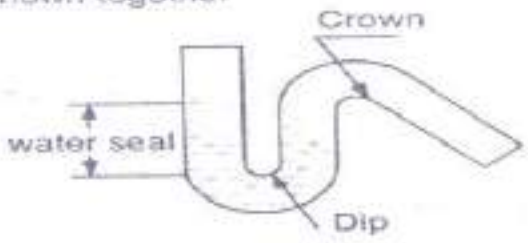
Above three types of traps are shown in the following figures.



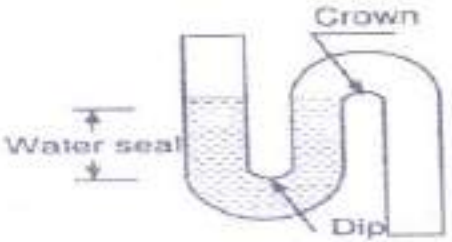
P,Q & S trap shown together



P-Trap



Q-Trap



S-Trap

Based on the Use, the traps are classified as:

- Floor Traps (Nahni Trap)
- Gully Traps
- Intercepting Traps
- All the above traps are discussed below

Floor Trap (Nahni Trap)

- **Floor Trap (Nahni Trap): This trap is generally used to admit sullage from the floors of rooms, bathrooms, kitchen etc**. in to the sullage pipe. This is provided with cast iron or **stainless steel or galvanised gratings (Jallis) at its top so that the entry of larger matter is prevented therby chances of blockage are reduced.** A commonly used name of trap is Nahni Trap.

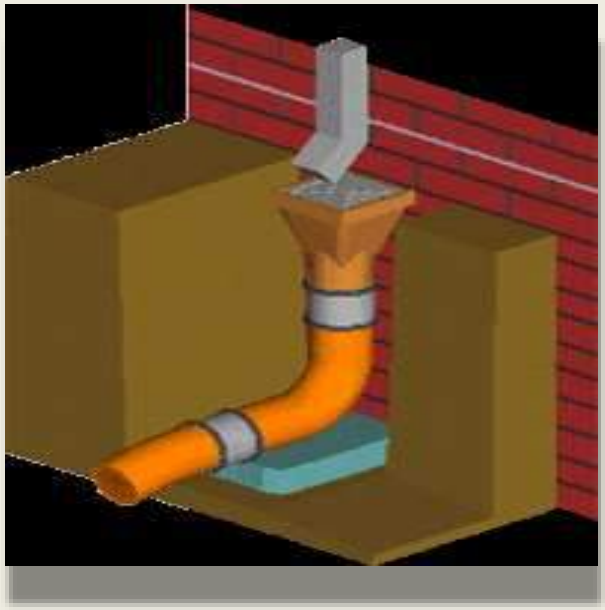
Nahni Trap

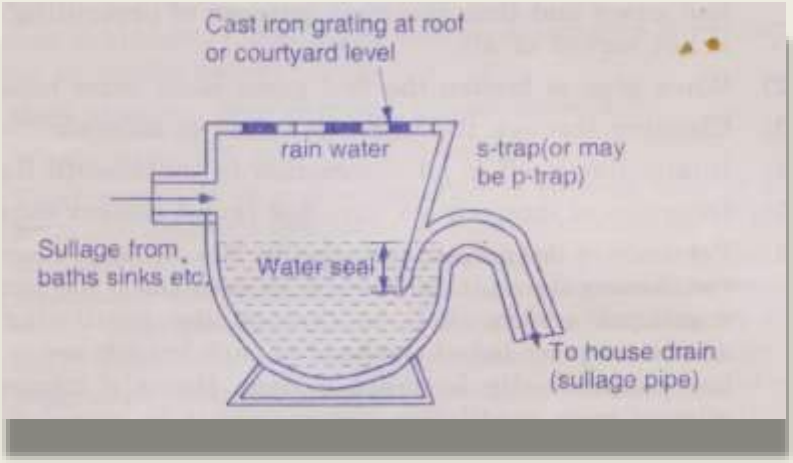
Gully Trap

- **A Gully trap or gully is provided at a junction of a roof drain and other drain coming from kitchen or bathroom.** As shown in figure below the foul sullage shall enter through the **side inlet which is also called as back inlet and unfoul rain water shall enter from the top which is covered with cast iron grating.**

  Gully traps may either have a P shaped or Q shaped water sealing arrangement. The water seal is normally 50 mm to 75 mm deep.

Gully Trap

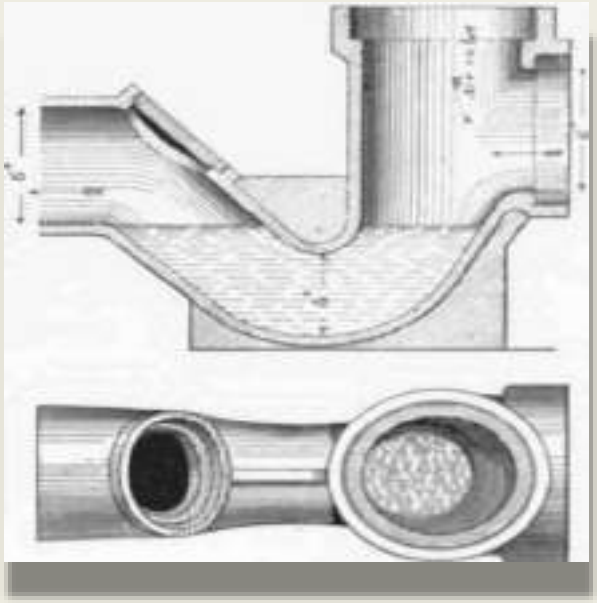


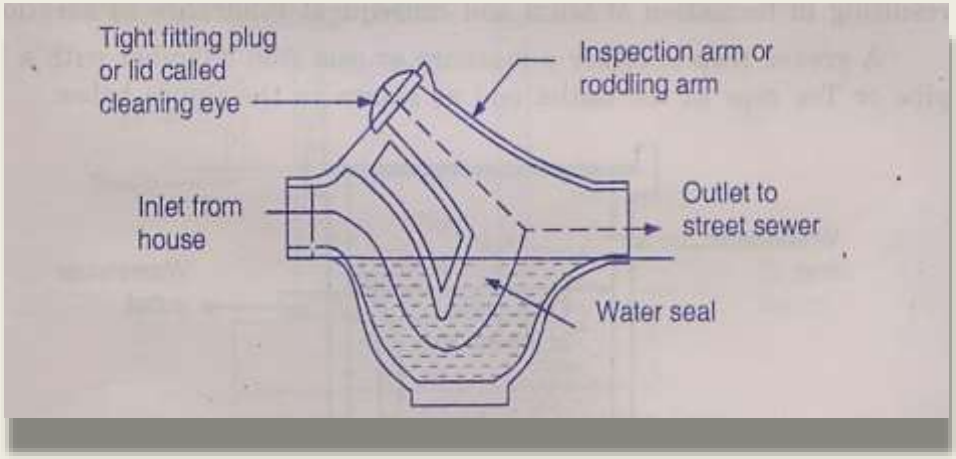

Cast iron grating at roof
or courtyard level
rain water
s-trap(or may
be p-trap)
Sullage from
baths sinks etc.
Water seal
To house drain
(sullage pipe)

Intercepting Traps

- **Intercepting Traps: Intercepting traps is provided at junction of a house sewer and muncipal sewer for preventing entry of foul gases of municipal sewer** in to the house drainage system. **Intercepting trap is provided in the manhole** as shown in the following figure.

Intercepting Traps





Advantage of Intercepting traps

- **Foul Gases of larger municipal sewers are prevented from entering house drainage** system.
- **Harmful pathogens are not entered in house drains.**
- **Well designed and contructed interceptors can quickly remove foul matter** of house drain to muncipal sewers.

Disadvantages

- **Heavy matter shall retain in the trap if the discharge of wastewater is small and the small decompose producing four gases** and thus the main purpose of preventing foul gases is not served at all.
- **When plug is broken the foul gases shall enter house sewers**.
- **Cleaning through the inspection area is difficult**.
- **Interceptor itself is an obstruction** to the smooth flow.
- **Omission of interceptor have not raised serious consequences**.
- **Presence of interceptor installed by the owner is found to affect ventilation of muncipal sewer**. Hence if interceptors are allowed more ventilation systems are to be provided for public or municipal sewers increased cost of sewerage system and there by increasing taxes too.
- **Because of the above reason the municipalities decide whether to allow the owner to provide intercepting traps or not.**

Grease Trap

- **These type of traps are used in large hotels restaurants or industries where large quantity of oils waste is generated.** If the oily or greasy matter is not seperated it will stick to the building drainage system resulting in formation of scum and consequent hinderance in aeration.
- **A grease trap is either a masonary or cast iron chamber with a bent pipe or Tee pipe at the outlet.**
- **There is sudden increase in area of flow at the inlet and hence the velocity of flow is reduced which results in seperation of oil and grease from wastewater.** The oil and grease floats on the surface and should be removed periodically.
- **A separate outlet pipe for oil and grease trap can be installed with a valve to stop the flow after complete removal of oil or grease** from the top suface.

Grease Trap

Pipes

- **In house drainage system pipes may be designated** depending upon the function as shown below.
- **Soil Pipe**: A pipe carrying human extracta
- **Waste Pipe**: A pipe carrying sullage
- **Vent Pipe**: It is a pipe installed to provide flow of air to or from the drainage system or to provide circulation of air in the drainage system to provide circulation of air in the drainage system to protect the water seal of traps against siponage and backflow.
- **Antisiponage Pipe**: It is the pipe which is installed to preserve the water seal in the trap through proper ventilation
- **Rain water Pipe**: A pipe carrying only rain water is called rain water pipe.

Sizes of Various Pipes

Type	Size
Soil Pipe	100
Waste Pipe (horizontal)	30 To 50
Waste Pipe (Vertical)	75
Vent Pipe	50
Rain water pipe	75
Antisiponage pipe	50 mm

Sanitary Fittings

- Following sanitary fittings are used in the house drainage system.
- ***Wash Basin***
- ***Sinks***
- ***Bath tubs***
- ***Water Closets***
- ***Urinals***
- ***Flushing Cisterns***

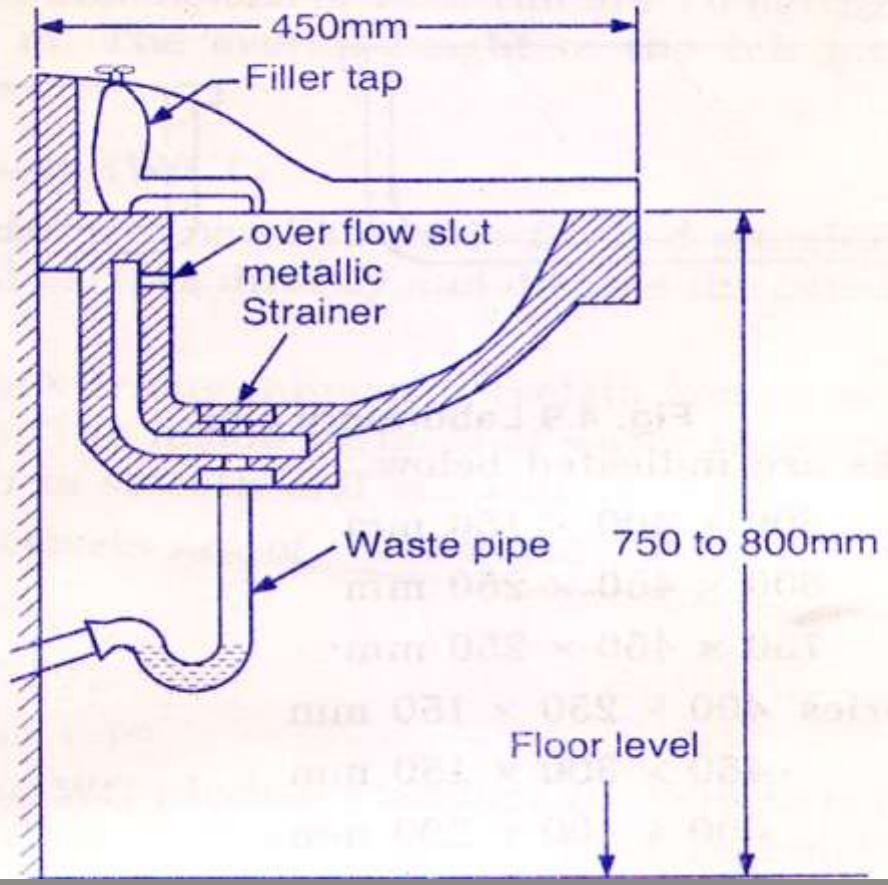
Wash Basins

These are plumbing fixtures mainly used for handwashing.

- These are normaly made of glazed earthernware or vitrious china. Sometimes they are also made from iron stainless steel or plastic, specially for the places where users are more.
- Wash basins may be either flat back pattern or angle back pattern. The previous is fixed on walls and latter is used for fixing at corners of walls. The flat back pattern has standard sizes as follows:
- **630 mm x 450 mm**
- **550mm x 400 mm**
- **450 mm x 300 mm**
- Where as the angle back pattern has standard sizes as shown below:
- **600 mm x 480 mm**
- **400 mm x 400 mm**

Wash Basin

Section of a flat back pattern wash basin is shown below.



Types of Wash Basins

Sinks

- **Sinks are the plumbing fixtures provided in kitchens for cleaning utensils.** Sinks are also provided in laboratories for cleaning laboratory glasswares etc. The plan and section of sink is shown below:
- Sizes of sinks are indicated below:
- For Kitchen
- **600 x 400 x 150 mm**
- **600 x 450 x 250 mm**
- **750 x 450 x 250 mm**
- For laboratories
- **400 x 250 x 150 mm**
- **450 x 300 x 150 mm**
- **600 x 400 x 200 mm**
- **500 x 350 x 150 mm**

Bath Tubs

- **Bath Tub is the plumbing fixtures provided in the bathroom for taking bath.** This is made of glazed earthware or viterious china, cement concrete finished with terrazzo or glazed procelain tiles or marbles and eamelled iron.
- **A circular waste hole at the bottom of bath tub is provided for drainage purpose.** The hole is provided with **a metallic waste fitting also called waste coupling having a strainer and clean opening of about 40 mm to 50 mm dia. A waste pipe is fixed to the waste fitting.**
- **The bath tub is provided with tap or shower and overflow pipe of 40 mm located at 40 to 50 mm** below the top edge of the tub.

Bath Tub

Water Closets (W/C)

- **A water closets is a pan like water flushed plumbing fixture designed to remove human excreta directly and dispose** the same in to the soil pipe through trap.
- **It is made of viterous china or proclain and is connected to soil pipe through the trap.** The inside surface of water closet and trap are glazed so that the flushing is smooth and efficient.
- ***The water closets are of three types:***
- ***India Type***
- ***European Type***
- ***Anglo Indian Type***

Indian Type WC

- **Indian Type WC: Indian standard IS 2556 Part III- 1990 provides detailed specification for the viterous china** Indian type water closets.
- Following fig shows the Indian type Water closets

Indian Type WC

- **It is simple in construction and working bat used in squatting position.** Usually it is made from procelain. The pan and trap are available in two different pieces. **The trap has an opening for antisiponage pipe. The WC is fixed in squatting position just at floor level.** Indian type WC requires around **10 litre of water** for flushing. The flushing cistern is fitted at **2 m height from the water closet.**

European Type Water Closet

- **Fig shows European type water closet**. It is usually made of proclain. **It is provided with seat and cover.** The pan has flushing rim to spread the flusing rim to spread the flush water. **The closet is fitted with P-trap or S Trap.**

Anglo Indian Type W/C

- **In the european W/C the user can not rest on thin rim conveniently and in indian W/C chances of fouling of excreta are more. The above disadvantages of european and indian water closets are removed in anglo Indian water closet.** The closet is **fixed 40 cm above from the floor level and upper rim of the pan is enlarged sufficiently so that user can conveniently sit .**

Anglo Indian Type W/C

Urinals

- **(Indian Standard IS 2556 part 6 1992 describes the detailed specification for the viterous urinals)**
- Urinals mostly in use are of two types:
- ***Bowl Type***
- ***Stall Type***

Urinals

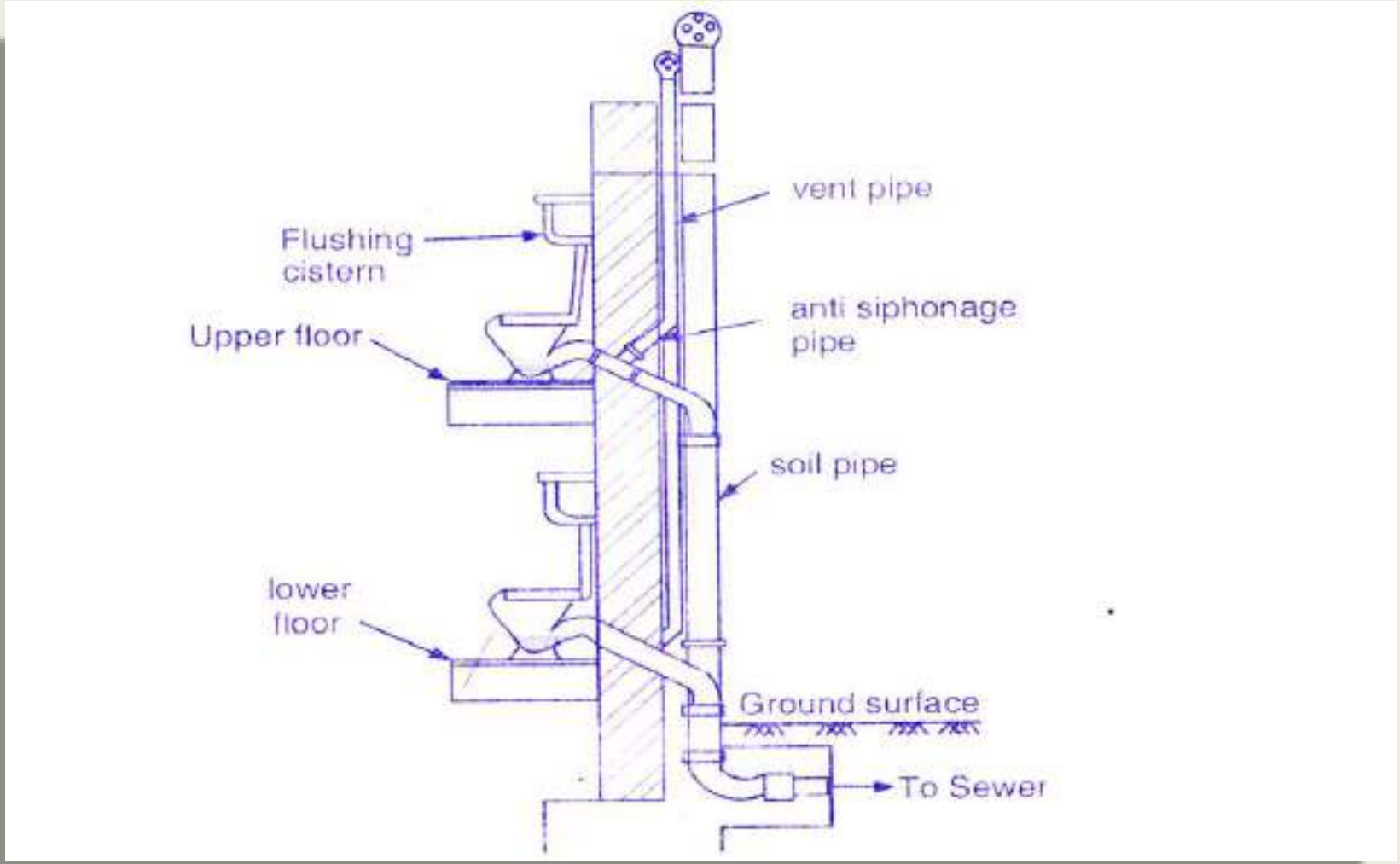
Flushing Cistern:

- **Indian Standards IS 774-1990 provides detailed specification from flushing cisterns** for water closets and urinals. Other than plastic cisterns.
- **The flushing cistern is installed to flush the water closet and urinal.** It is made of cast Iron, glazed earthenware or viterous china or plastic. For Indian WC the flushing cisterns are made from **cast Iron and fixed at a height of about 1.75 m above the top of closet pan**. They are known as high level flushing cisterns
- **For european and anglo Indian type water closets, normally vitreous china or plastic cisterns are used.** The cisterns are fixedwith their bottom at only **height of about 30 cm** from the top of the pan. They are therefore known as low level flushing cisterns.

Flushing Cistern:

- Flushing cisterns are classified as
- ***Siponic without valve***
- ***Siponic with valve***

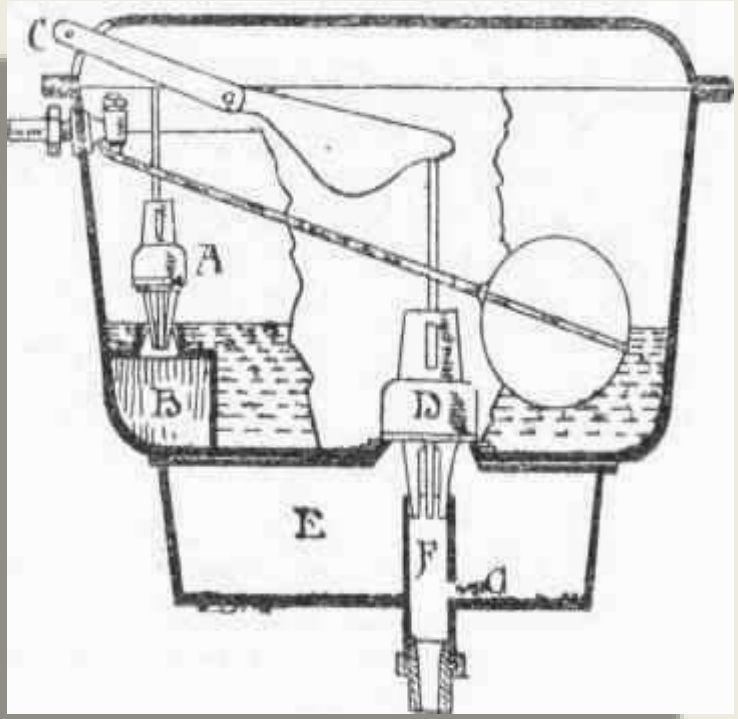
Flushing Cistern



Bell Type flushing

- **Bell type flushing cistern shown below is used with Indian WC. It doesn't have valve**.
- Bell type flushing cistern consists of following parts.
- ***Bell***
- ***Float***
- ***Lever with chain***
- ***Inlet outlet and overflow pipes***
- ***Cast Iron casing***

Flushing Cistern



Bell Type flushing

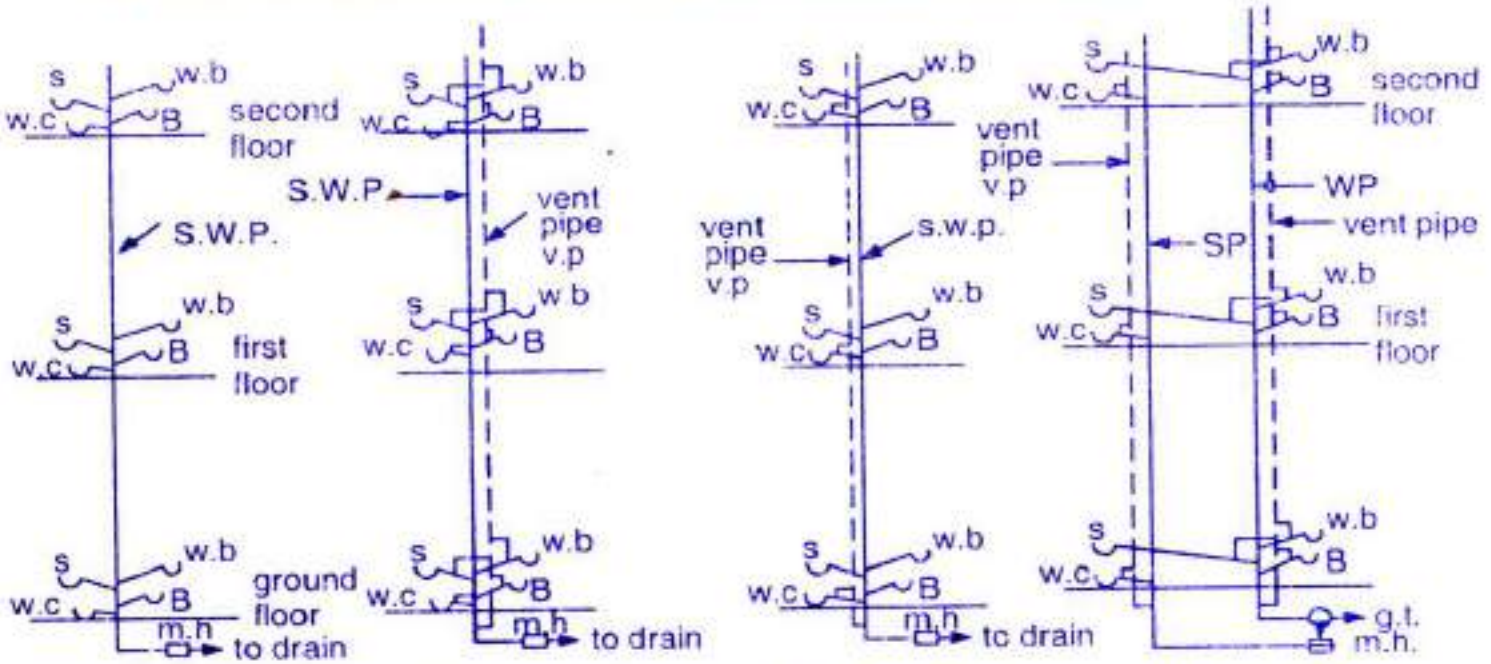
- **The function of the cistern is based on principle of siphonic action.** When the float is at bottom the inlet valve is open and water enters the cistern when water level rises the float also rises and at a certain water level the inlet valve is closed.
- **When the chain is pulled the bell connected it through lever, is lifted up and water splashes inside the bell through the bottom of the bell which carries some air with it and as a result of that partial vaccum is created** in the bell which generates the siphonic effect and water continiously flow in the flush pipe through its bottom and siphonic action stops. **As the cistern is emptied float comes down and inlet valve is opened allowing water to flow in the cistern.**

System of Plumbing for House Drainage

- **There are four plumbing systems for house drainage**
- ***Single Stack System***
- ***One pipe system***
- ***Single Stack Partially Ventilated System***
- ***Two Pipe system***
- All the systems are shown in the following figures

System of plumbing and house Drainage

All the systems are shown in the following figure.



(a) Single stack system (b) One pipe system (c) Single stack partially ventilated (d) Two pipe system

w.c. = Water closet; B = Bath tub, w.b. = Wash basin; s = Kitchen sink; v.p. = Vent pipe; S.W.R. = Soil and Waste pipe; S.P. = Soil pipe; W.P. = Waste pipe; M.H. = Manhole; g.t. = Gully Trap

Note : All pipes terminate as vent pipes at the top.

Single Stack System

- From the figure it is clear that only single pipe acts as soil pipe waste pipe and ventilation pipe.
- ***This is poorly ventilated system***
- ***It is simple system and easy to construct.***
- ***Risk of water seal breaking in the trap is high because of induced siponage.***
- ***Waste or air of the waste pipe may be forced up due to back pressure.***

One Pipe System

- **A Separate vent pipe is provided in this system.** It is clear from the study of sketch that in comparision to single stack system:
- ***This system is costly and difficult to construct***
- ***Ventilation is provided to sullage pipe and soil pipe too.***
- ***Arrangement of pipe work is difficult.***

Single Stack Partially Ventilated System

- Following are the features of this system.
- ***Only water closet traps are ventilated.***
- ***Traps of baths, washbasins and kitchen are not joined with vent pipe.***
- ***This is economical system***
- ***It is required to maintain water seal of 75 mm or more.***
- ***It has simple arrangement of pipe.***

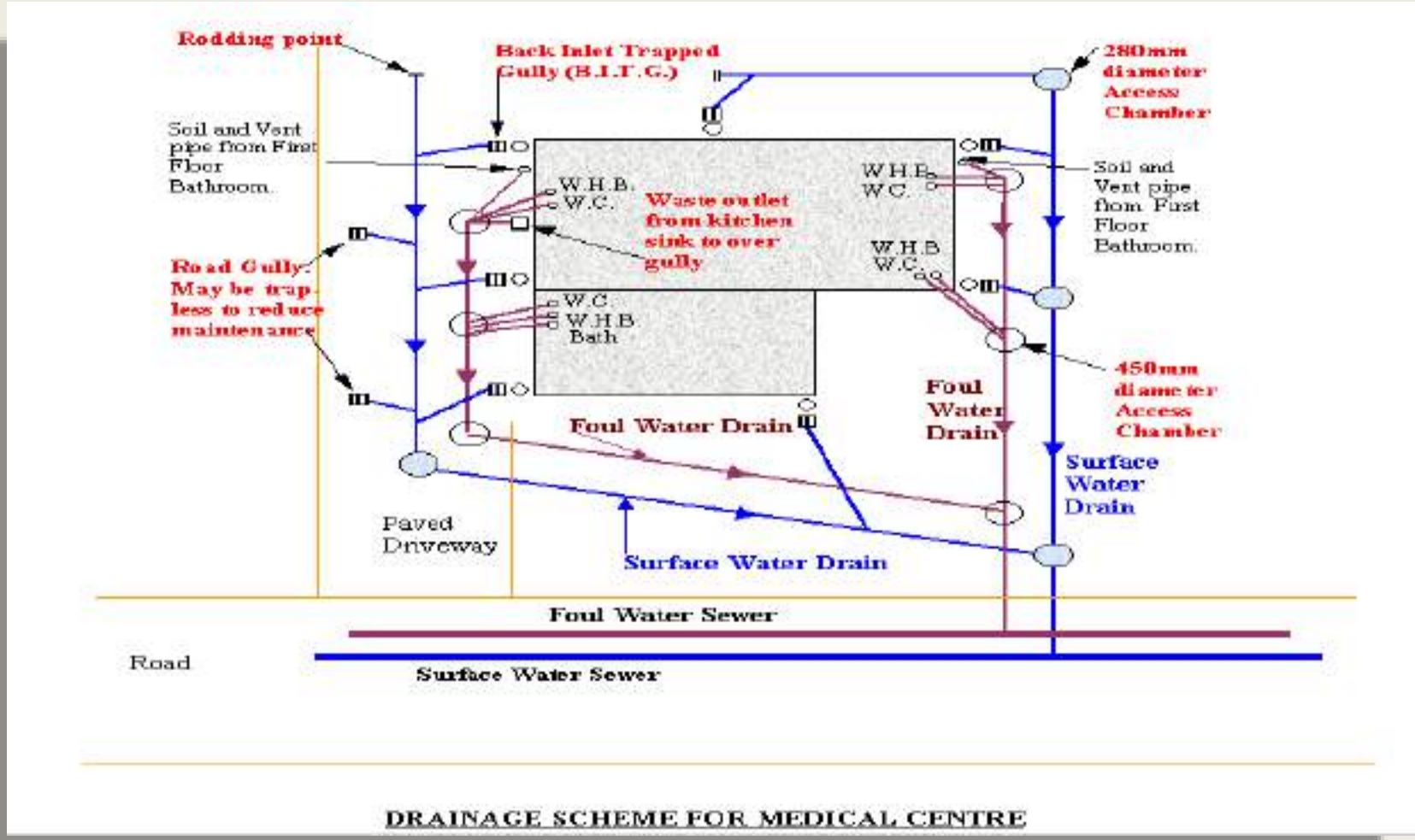
Two Pipe System

- Following are the features of this system.
- ***Water closets, bath traps, kitchen traps and wash basin traps all are connected to vent pipes.***
- ***Separate soil pipe and waste pipes are provided.***
- ***Two vent pipes are provided.***
- ***There are four stakes in this system***
- ***It is efficient system but costlier than other systems.***

House Drainage Plan

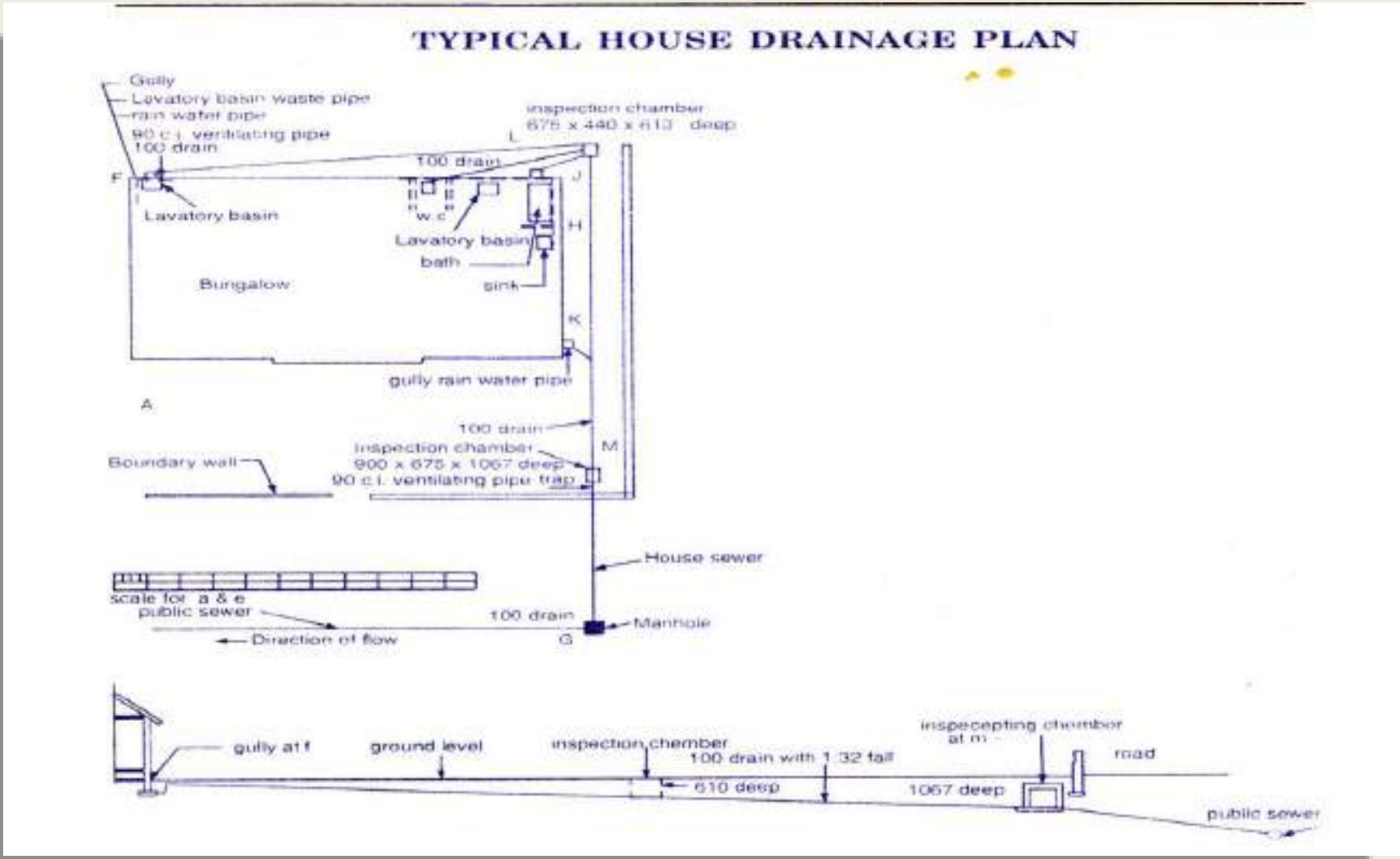
- **Important points to be considered while preparing house drainage plan are mentioned below.**
- ***Drainage layout plan should be as simple as possible****. Pipes should be laid in straight line.*
- ***Both vertical and horizontal pipes shall be laid in straight lines as far as possible.***
- ***Where there is change in the direction of pipe, inspection chamber or manhole should be provided.***
- ***Sewers should not be laid under a building to avoid the risk of decrease in bearing capacity in case of continious leakage of sewage from joints.*** *The leaked sewage percolates in the soil and increase moisture content of soil below the foundation. Increased moisture content decreases bearing capacity which is not desirable.*
- ***Pipes should be laid at proper gradient and proper size. The usual size of house sewer are 100 mm, 150 mm, 230 mm, and 300 mm.*** *they should be laid with such a gradient that there is no deposit of solid matter.*

House Drainage Plan



DRAINAGE SCHEME FOR MEDICAL CENTRE

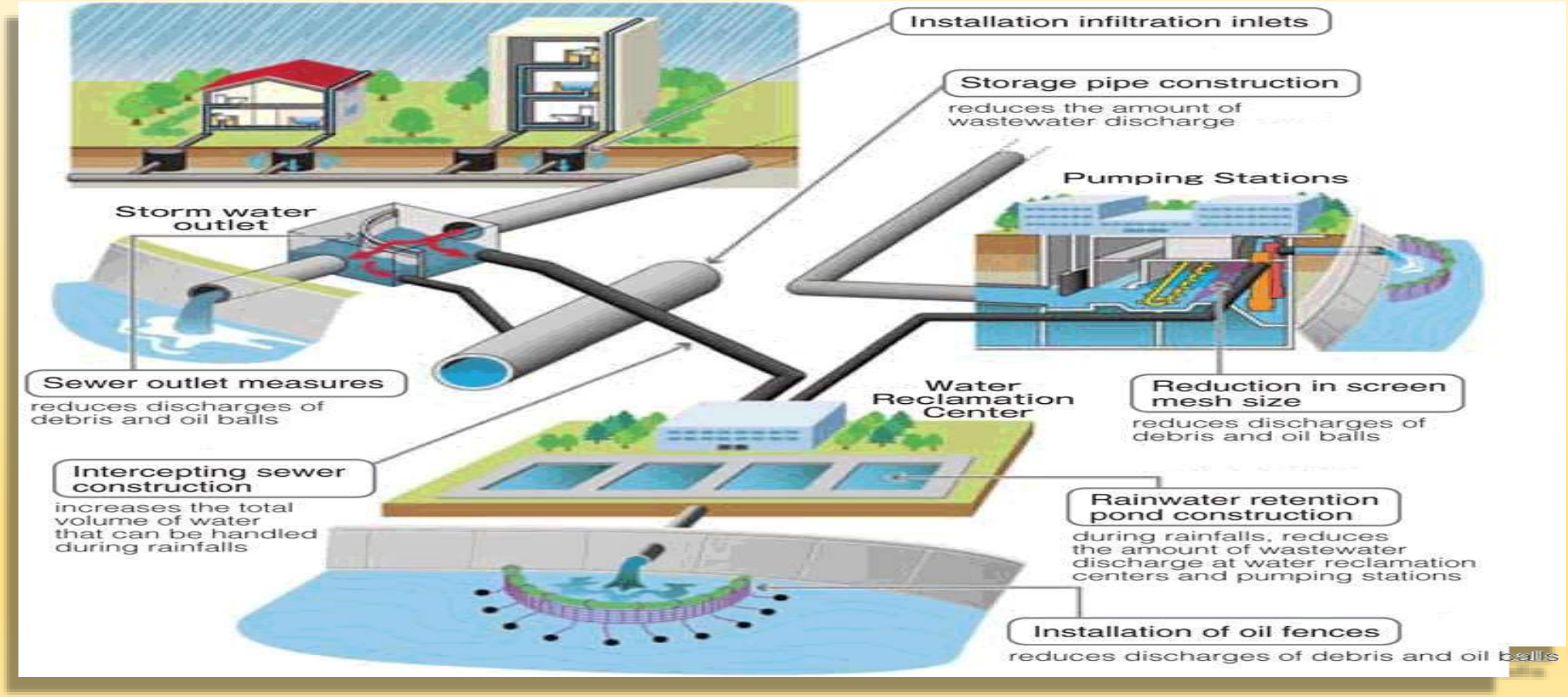
House Drainage Plan



Collection & Conveyance of Systems of Sanitation.

- For the disposal of waste products of towns two works are required"
- Collection Works
- Disposal Works
- The disposal works mainly consist of treatment works which are essential to treat waste water and dispose it off in such a way that it may not cause any harm to the health of public nor pollute the nearby water sources. The collection works are the works which are done to collect the waste products. In olden days it was done by conservancy method, but in modern cities it is done by water-carriage method.

Collection & Conveyance of Systems of Sanitation

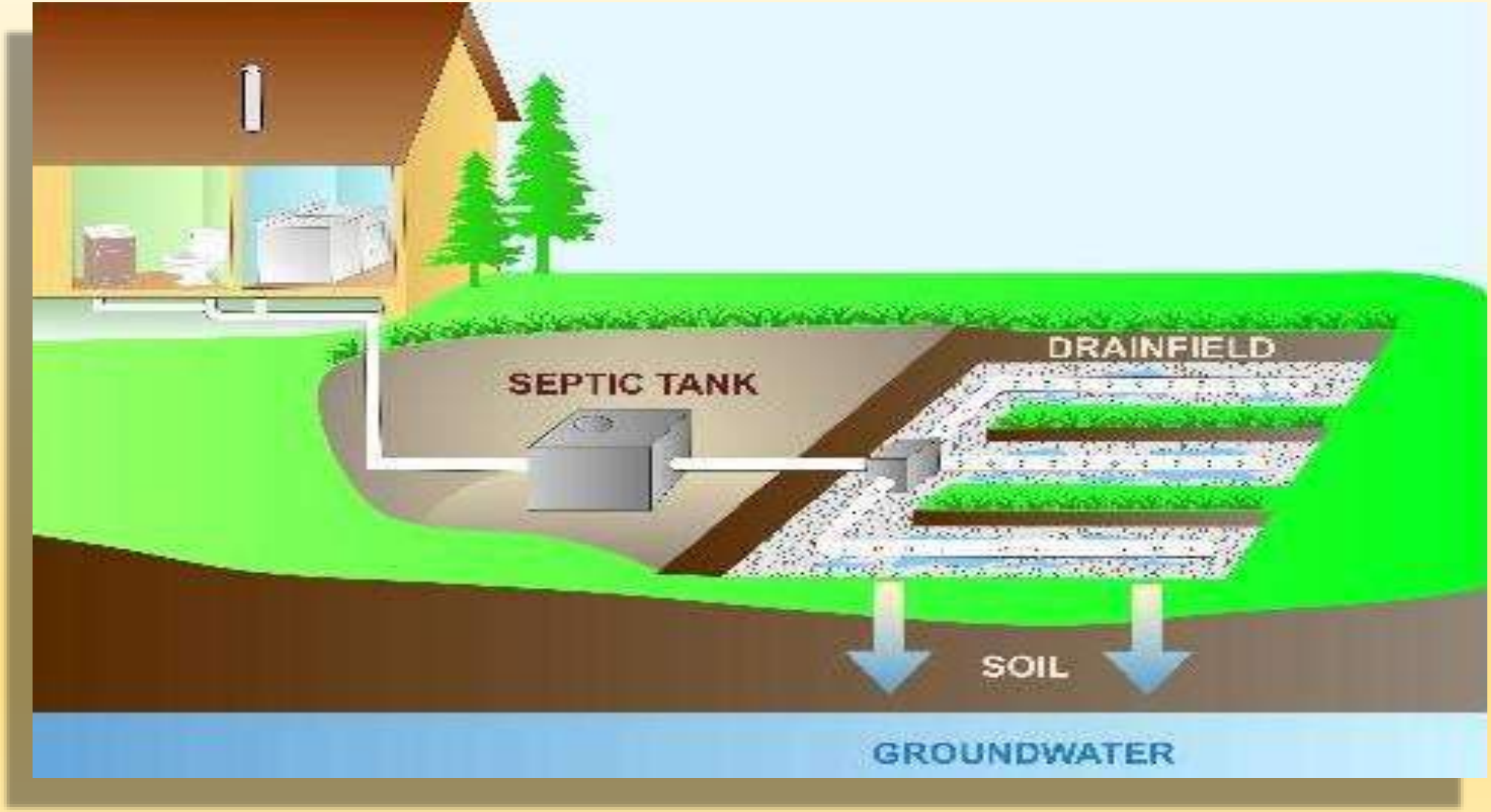


Collection & Conveyance of Systems of Sanitation.

Methods of Collection

- The sanitation of town or city is done by two methods:
- Conservancy System
- Water-Carriage System

Conservancy System



Collection & Conveyance of Systems of Sanitation.

Conservancy System

- Sometimes this system is also called dry-System. This system is in practice from very ancient times. Actually it is out of date system even though it is prevailing in small towns, villages and undeveloped portions of the large cities. Various types of refuse and storm water are collected, conveyed and disposed of separately by different methods in this system, therefore, it is called conservancy system.

Collection & Conveyance of Systems of Sanitation.

- Garbage or dry refuse of a town is collected in dust bins placed along the roads and streets, from where it is conveyed by trucks or covered carts once or twice in a day to the point of disposal.
- All the non-combustible portions of the garbage such as sand, dust, clay ashes etc., are used for filling the low level areas to reclaim land for further development of the town. **The combustible portion of garbage such as dry leaves, waste paper, broken furniture etc. are burnt. The decaying fruit and vegetables, grass and other things are first dried and then disposed of by burning or in the manufacturing of Manure.**

Collection & Conveyance of Systems of Sanitation.

- **Human Excreta or Night Soil is collected separately in privies or conservancy laterins**. The liquid and semi-liquid wastes are collected in separate drains of the same latrine, from where they are removed through human agency.
- **The night soil is taken outside the town in closed animal drawn carts, trucks or tanks mounted on the trailers**. The night soil is buried in trenches.
- In conservancy system the Sullage and Storm waters are also carried out separately in closed or open drains, upto the point of disposal, where they are allowed to mix with stream, rivers or sea without any treatment.

Collection & Conveyance of Systems of Sanitation.

Merits of Conservancy System

- The following are the merits of Conservancy System
- It is cheaper in Initial cost because storm water can pass in open drains and conservancy latrines are much economical.
- The quantity of sewage reaching at the treatment plant before disposal is low.
- As the storm water goes in open drains, the sewer section will be small and will run full for the major portion of the year, due to which there will be no silting and deposits in sewer-lines.
- In floods if the water level of river rises at the out-fall, it will not be costly to pump the sewage for disposal

Collection & Conveyance of Systems of Sanitation.

Demerits

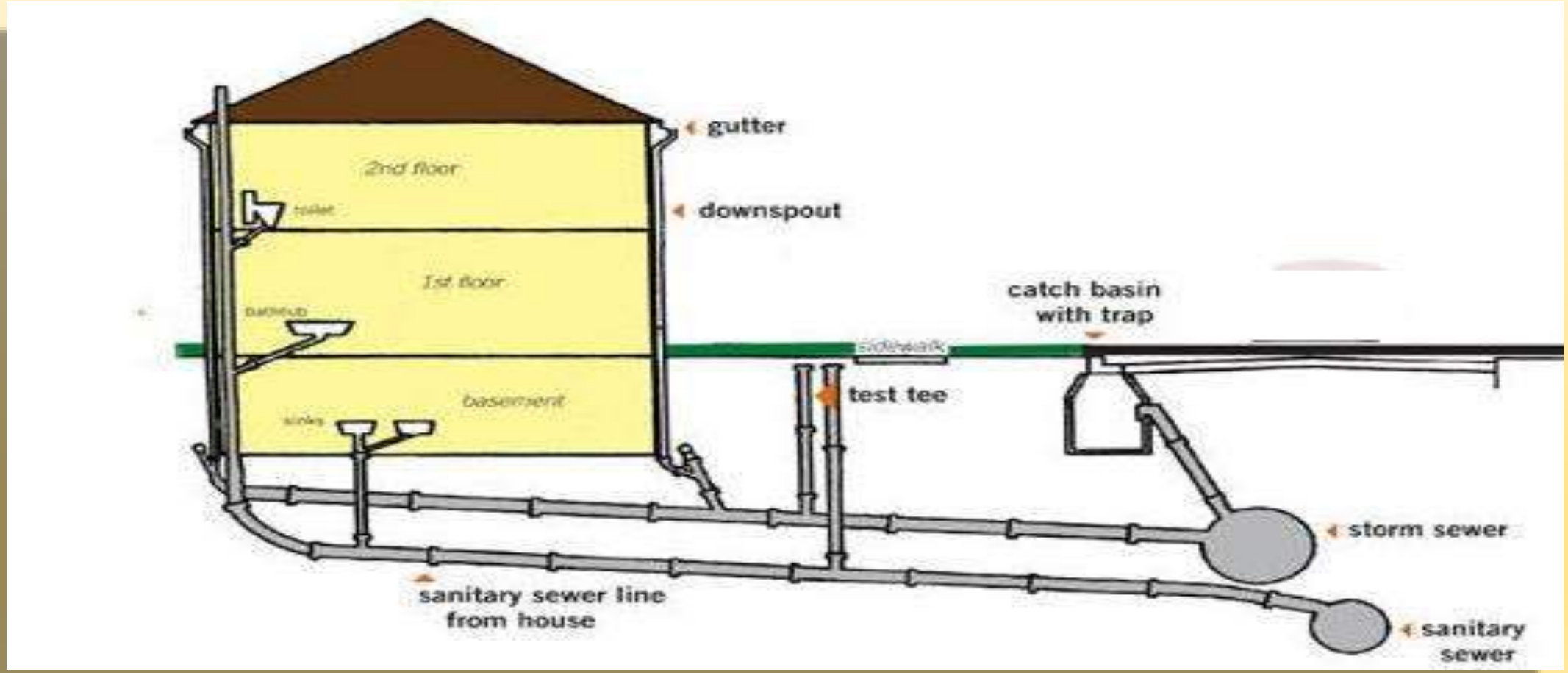
- It is possible that storm water may go in sewer causing heavy load on treatment plants, therefore it is to be watched.
- In crouded lanes it is very difficult to lay two sewers or construct road side drains, causing great inconvenience to the traffic.
- Buildings cannot be designed as compact unit, because latrines are to be designed away from the living rooms due to foul smell, which are also inconvenient.
- In the presence of conservancy system, the aesthetic appearance of the city cannot be increased.
- Decomposition of sewage causes insanitary conditions which are dangerous to public health.
- This system completely depends on the mercy of sweepers.

Collection & Conveyance of Systems of Sanitation.

Water Carriage System

- With the development and advantages of the cities, urgent need was felt to replace conservancy system with some more improved types of system in which human agencies should not be used for the collection and conveyance of the sewage. After a large number of trials it was found that the water is the only cheapest substance, which can be easily used for collection and conveyance of sewage. Therefore it is called Water-Carriage System.
- **In this system the excremental matters are mixed up in large quantity of water and are disposed off after necessary treatment in a satisfactory manner.**

Collection & Conveyance of Systems of Sanitation.



Collection & Conveyance of Systems of Sanitation.

Merits & Demerits of Water Carriage System

Merits

- It is hygienic method, because all the excremental matters are collected and conveyed by water only and no human agency is employed for it.
- There is no nuisance in the street of the town due to offensive matters, because all the sewage goes in closed sewers under the ground. The risk of epidemic is reduced.
- As only one sewer is laid, therefore it occupies less space in crowded lane.
- Due to more quantity of sewage, self-cleansing velocity can be obtained even at less gradients.
- Buildings can be designed as compact one unit.
- The land required for the disposal work is less as compared with conservancy system in which more area is required.
- The usual water supply is sufficient and no additional water is required in water carriage system.
- This system does not depend on the manual labours
- Sewage after proper treatment can be used for various purposes.

Collection & Conveyance of Systems of Sanitation.

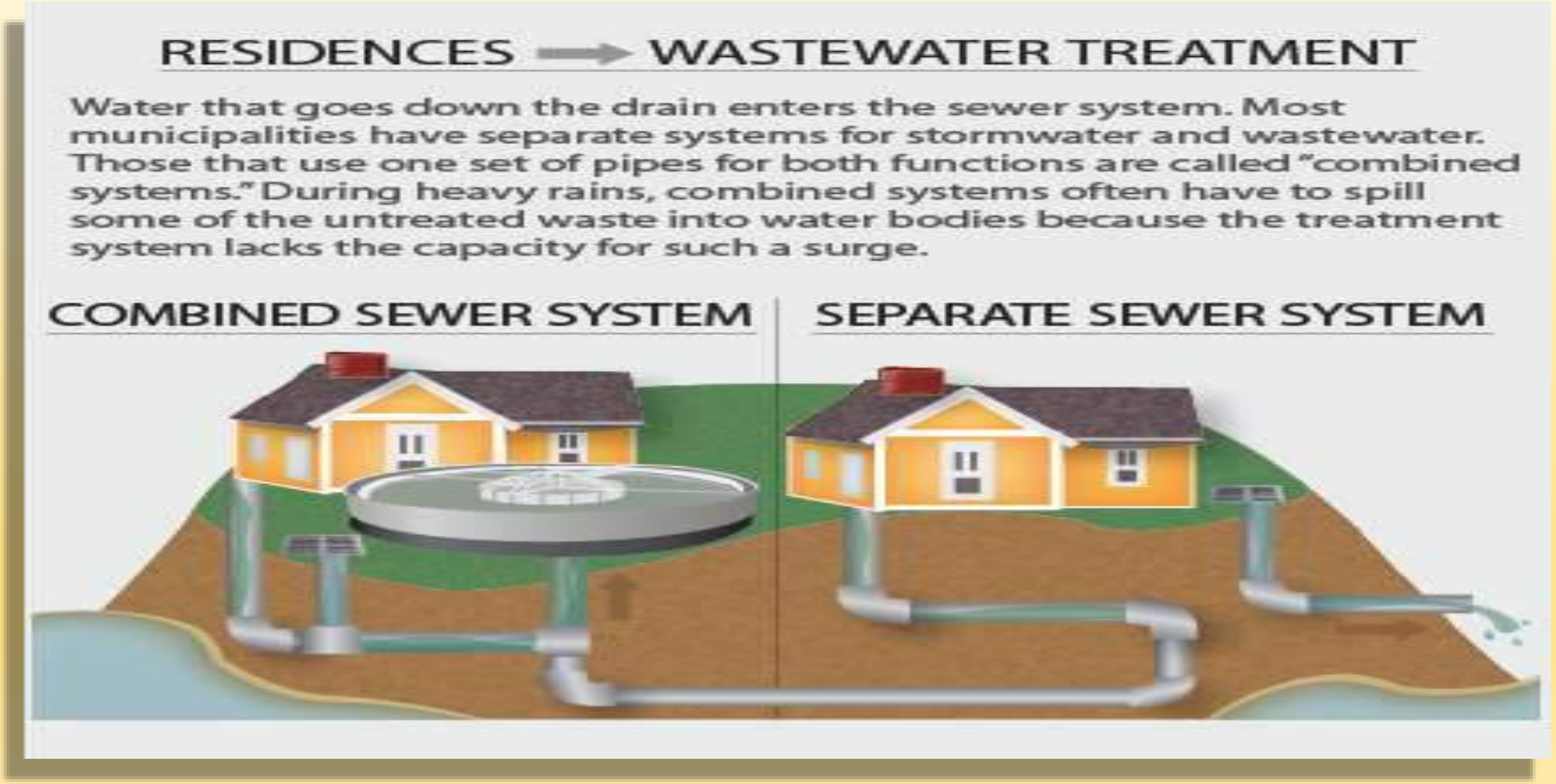
Demerits

- The following are the demerits of water carriage System
- This system is very costly in initial cost.
- The maintenance of this system is also costly.
- During monsoon large volume of sewage is to be treated whereas very small volume is to be treated in the remaining period of the year.

Sewerage System

- The Sewerage System are classified as follows:
- **Combined System**
- **Separate System**
- **Partially Separate System**
- When only one set of sewer is laid, carrying both the sanitary sewage and storm water it is called combined system.
- In the separate system, if a portion of storm water is allowed to enter in the sewers carrying sewage and the remaining storm water flows in separate set of sewers it is called partially separate system.
- The combined system is most suited in areas having small rainfall which is evenly distributed throughout the area, because at such places self-cleaning velocity will be available in every season. As only one sewer is laid in this system, therefore it can also be used in crowded areas, where it is very difficult to lay two sewers.
- If rainfall is heavy and it is for short time, it is better to provide separate system, because in combined system self cleaning velocity will not be available for most of the period of the year

Sewerage System



Sewerage System

Merits and Demerits of Separate System

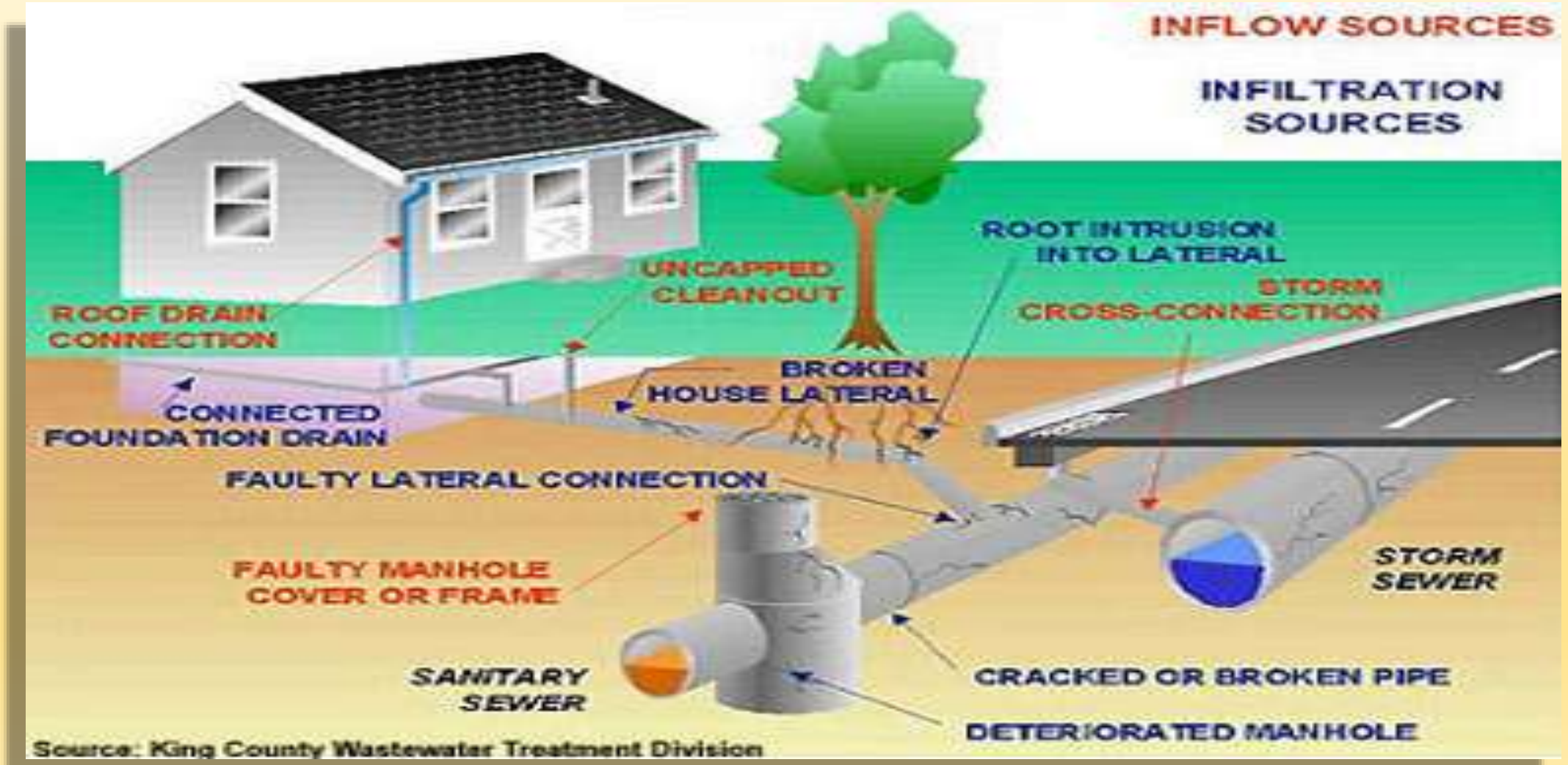
- Followings are the merits of Separate System
- The sewage flows in separate sewer, therefore the quantity to be treated is small which results in economical design of treatment works.
- Separate system is cheaper than combined system, because only sanitary sewage flows in closed sewer and the storm water which is unfoul in nature can be taken through open gutter or drains, whereas both types of sewage is to be carried in closed sewer in case of combined system
- During disposal if the sewage is to be pumped, the separate system is cheaper.
- There is no fear of stream pollution

Sewerage System

Followings are the demerits of separate System

- Generally self-cleaning velocity is not available, due to small quantity of sewage, therefore flushing is required at various points.
- There is always a risk that storm water may enter the sanitary sewer and cause over flowing of sewer and heavy load on the treatment plant.
- As two sets of sewer are laid, therefore its maintenance cost is more.
- In busy lanes laying of two sewers is difficult which also causes great inconvenience to the traffic during repairs.

Sewerage System



Sewerage System

Merits and Demerits of Combined System

- Merits of Combined System
- There is no need of flushing, because self-cleansing velocity is easily available at every place due to more quantity of sewage.
- Rain water dilutes the sewage, therefore it can be easily and economically treated.
- House plumbing can be done easily because only one set of pipes will be required
- The following are the demerits of Combined System
- Initial cost is high as compared with separate System
- It is not suitable for areas having rainfall for small period of the year, because the dry weather flow will be small due to which self-cleaning velocities will not be available resulting in silting up of the sewers.
- If the whole sewage is to be disposed off by pumping, it is uneconomical
- During heavy rains, the overflowing of sewers will endanger the public health.

Merits and Demerits of Partially Separate System

Following are the merits of Partially Separate System:

- As it is an improvement over separate System, economical and reasonable size of sewers are required.
- The work of house-plumbing is reduced, because the rain water from roof, sullage from bath and kitchens etc. can be taken in the same pipe carrying the discharge from the water closets.
- No flushing is required, because the quantity of sewage is increased as small portion of storm water is allowed to enter in sanitary sewage.

Merits and Demerits of Partially Separate System

Following are demerits of partially Separate System

- The Cost of Pumping is Increased at disposal plants than separate system because a portion of storm water is mixed with sanitary Sewage.
- There are possibilities of overflow, requiring storm overflows.
- In dry weather, the self cleaning velocities may not develop.

Collection & Estimation of Wastewater

Different types of Sewers:

- Following are different types of sewers classified on the basis of wastewater carried by them and their size:
- Soil pipe
- It is the pipe carrying sewage from latrine in a house drainage system. It is one of the component of a house drainage system
- Waste Pipe
- It is the pipe carrying wastewater from bathrooms sinks and kitchens, it is one of the components of house drainage system
- Lateral sewer
- It is sewer receiving domestic wastewater from house sewer. It is one of the component of sewerage system of a town or city.

Collection & Estimation of Wastewater

House Sewer

- In house drainage system the domestic wastewater of a house is carried by the house sewer to the municipal sewer called lateral. House sewer is one of the component of house drainage system.

Branch Sewer

- The sewer which receives water from laterals sewers is called as branch sewer. It is one of the component of sewerage system of a city or town.

Main sewer

- A main sewer is the sewer which receives wastewater from the branch sewers. It is one of the component of a sewerage system of a city or town.

Collection & Estimation of Wastewater

Outfall Sewer

- The sewer conveying wastewater to the treatment plant is known as outfall Sewer.

Collection & Estimation of Wastewater

Classification of sewers based on materials used for their construction

- Sewers can also be classified on the basis of materials used for their construction. Various materials are used for sewer construction and each may be suitable for various Conditions.
- Following material are found to be suitable for the sewer construction
- Bricks
- Vitrified Clay
- Cement Concrete
- Asbestos Cement
- Cast Iron Sewer Pipes
- Plastic
- Glass fiber reinforced Plastic

Collection & Estimation of Wastewater

- Sewers made from the above material are
- Brick Sewer
- Stoneware or vitrified Clay Sewers
- Asbestos Cement Sewers
- Cement Concrete
- Plastic Sewer Pipes
- Glass fiber reinforced plastic Sewer Pipes.

Collection & Estimation of Wastewater

Brick Sewers

- Brick Sewer is Quite Cheap as a sewer material. It is locally available and gives moderately smooth surface. Bricks are also useful in construction of sewers appurtenances structures like manholes. With the help of bricks, sewers of various shapes like circular, void, basket handle type can be constructed at the site.
- Cement mortar joints in brick sewers may give some problems of corrosion because cement react with the gases liberated from faecal matter containing wastewater and is subjected to corrosion.
- There are some other disadvantages of brick sewers, they cannot be constructed rapidly. However bricks sewers are found to be suitable for large size of sewers carrying storm water or combined wastewater.

Brick Sewers

Collection & Estimation of Wastewater

Vitrified Clay

- Vitrified Clay is a product of clay. This material is widely used for manufacturing of sewers. The surface of vitrified clay sewer is very smooth and impervious and has high durability. The material has high resistance to corrosion and erosion, it is easily available and has good performance.
- Vitrified clay sewers pipes are used for small sewage discharges and hence their diameter are also small. Their maximum dia is restricted up to 60 cm
- Normally vitrified clay sewer pipes are constructed for 60 and 120 m lengths having socket and spigot type of joints

Vitrified Clay

Collection & Estimation of Wastewater

Cement Concrete Sewer Pipes

- Cement Concrete Sewer pipes are gaining more popularity, specially when the sizes of sewers are very large, because of high strength and comparatively low cost. They suit almost every condition of construction. Cement concrete may be made up of either plain or reinforced cement concrete, depending upon the size and the strength requirement.
- They may be precast or cast in Situ.
- The corrosion of concrete sewer pipes is mainly due to the acidic industrial wastewaters and hydrogen sulphide produced due to anaerobic decomposition of the organic matter with sulphate content.

Cement Concrete Sewer Pipes

Collection & Estimation of Wastewater

- **The following precautions can be taken to prevent the corrosion of Concrete Sewer Pipes.**
- Partial Purification of Wastewater to reduce Sulphur.
- Raising Oxidation Reduction potential by adding nitrate or nitro compounds.
- Aeration
- Chlorination
- Dosage of Copper, iron or Zinc to throw away sulphur compounds
- Application of protective Coating.
- Provision of good Sewer Ventilation System
- Sewers may be designed to run full.

Collection & Estimation of Wastewater

- As per IS 458 1971 Concrete pipes for drainage works are classified as below

Class of Pipe	Description	Condition Where Used
NP1	Unreinforced Concrete non pressure Pipes	For drainage or irrigational Use above ground or shallow trenches
NP2	Reinforced Concrete light duty non Pressure Pipes	For Drainage or Irrigational Use for culverts carrying light traffic
NP3	Reinforced Concrete Heavy duty non pressure pipes	For drainage and irrigation use for culverts carrying heavy traffic
NP4	Reinforced Concrete heavy duty pressure pipes	For drainage and irrigational use for culverts carrying heavy traffic.

Collection & Estimation of Wastewater

Steel Pipe Sewers

- Steel pipe sewers are used where lightness, imperviousness and resistance to bursting pressure are the major requirements. Steel Pipes have Unique quality of absorbing shocks and high external pressure by deflecting, bulking and flattening without failure. Steel pipes are available in riveted and welded sections.
- The corrosive and erosive actions can be prevented by bituminous coating to the internal surface.

Steel Pipe Sewers

Collection & Estimation of Wastewater

Asbestos Cement Pipe Sewers

- These type of sewer are manufactured from the cement and asbestos fibres. There are light weight smooth and durable. They can be sustain moderately good internal pressure. They can easily be cut, drilled, jointed & fitted. They are brittle and hence unable to bear the external loads. They are often used as rain water pipes in house drainage.

Cast Iron Sewer Pipes

- When extra strength is required, cast iron pipes are used as sewer pipes. They are strong against internal pressure and external loads Cast iron pipes are smooth durable and strong but they are costly and heavy.

Plastic Sewer Pipes

- Plastic pipes are Used Mainly in house Drainage System, Plastic pipes are available in Various Diameters ranging from 25 mm to 100 mm

Collection & Estimation of Wastewater

Collection & Estimation of Wastewater

Glass fiber reinforced plastic Sewer Pipes

- There are also known as GRP pipes. These type of sewer pipes are made from polyester resin, glassfibre, and sometimes silica sand is used as filler.
- The several major advantages of these pipes are.
- **Light Weight**
- **Easy to handle**
- **Smooth Surface Hence less headloss**
- **Faster installation and hence less time required.**
- **Repair work can be done quickly.**
- **These pipes are costlier than other pipes and therefore their use is not economical and hence nor recommended.**

Glass fiber reinforced plastic Sewer Pipes

Sewer Sections

Sewer

- For Conveying foul Discharges from Water-Closets of public and domestic buildings chemical mixed water from industries, closed conduits are required which can carry these foul matter without creating any nuisance outside the town. These conduits are called sewers and are laid underground. Connections from public, domestic and industrial buildings are made to these sewers which carry foul matter.
- Sewers should have such a cross section that self cleaning velocity should be developed even during dry weather flow. No deposits should settle down in the bed of sewers under any circumstances

Sewer Sections

Sewer Sections

Old Rectangular

- These were used in ancient times and are not used nowadays. It was constructed by laying concrete in the bottom and constructing sides with stone or brick masonry and then plastering.

New Rectangular

- This is constructed with R.C.C. which may be precast or Cast in Situ.

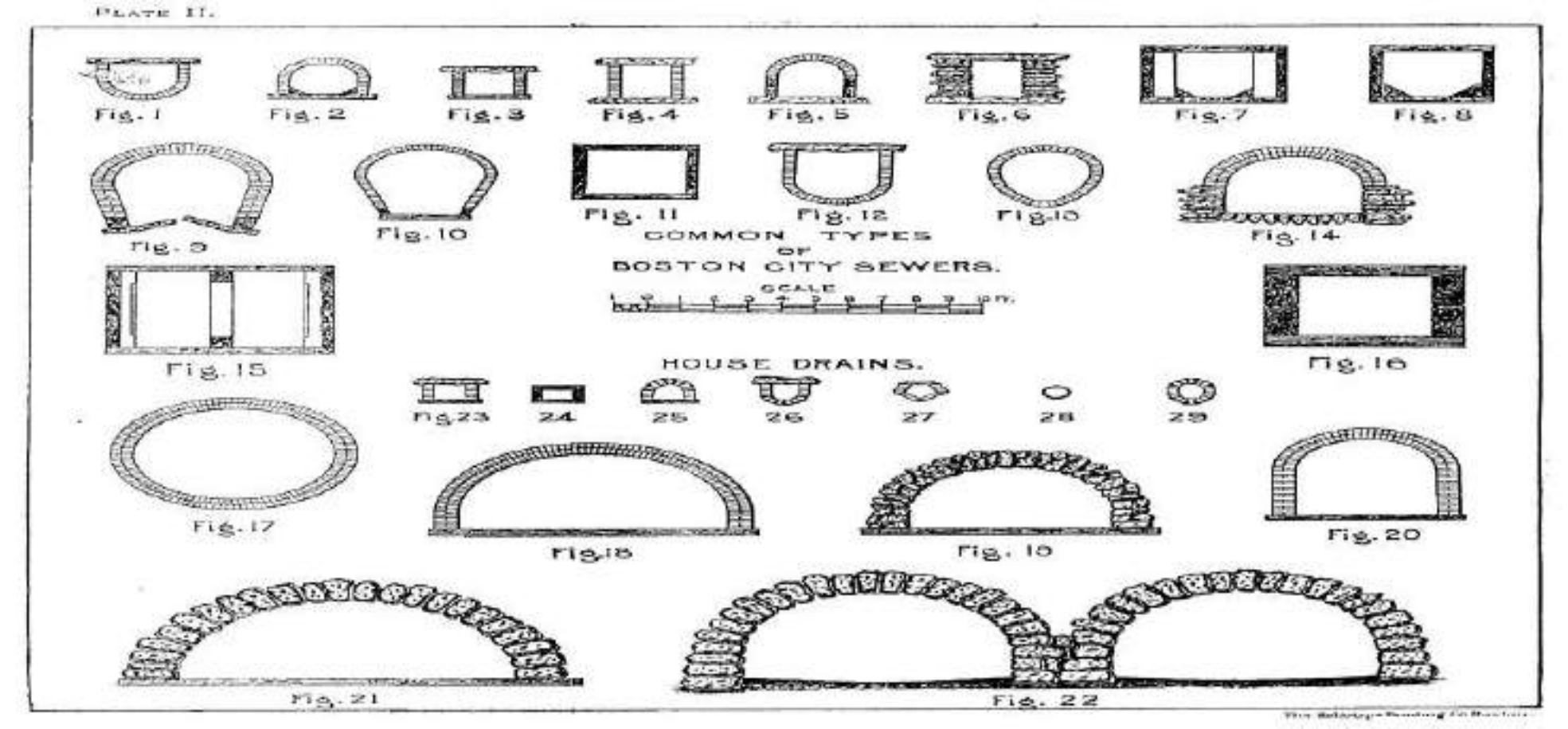
Circular Brick-Sewer

- This type of section is used under culverts and at such places where big diameter is required for short lengths. These sections are plastered from inside. Now a days these are not used due to their much wear and difficult centering.

Circular Pipes

- Precast asbestos cement concrete pipes reinforced with steel are mostly used now a days. Sometimes steel pipes with lining of cement concrete on inside and outside are used. Cast Iron pipes are also used on large scales for branch sewers.

Sewer Sections



Sewer Sections

Semi-Elliptical

- This Section is suitable for sewers Carrying large Discharges throughout the Year. These are Usually Constructed with R.C.C.

Horse Shoe Type

- This is constructed withR.C.C and is used in case of heavy discharges. Usually it has semi-Circular or parabolic in section. Its height is less than width.
- **Basket Handle** The shape of this section is similar to the basket handle therefore it is called as Basket Handle Type.

Sewer Sections

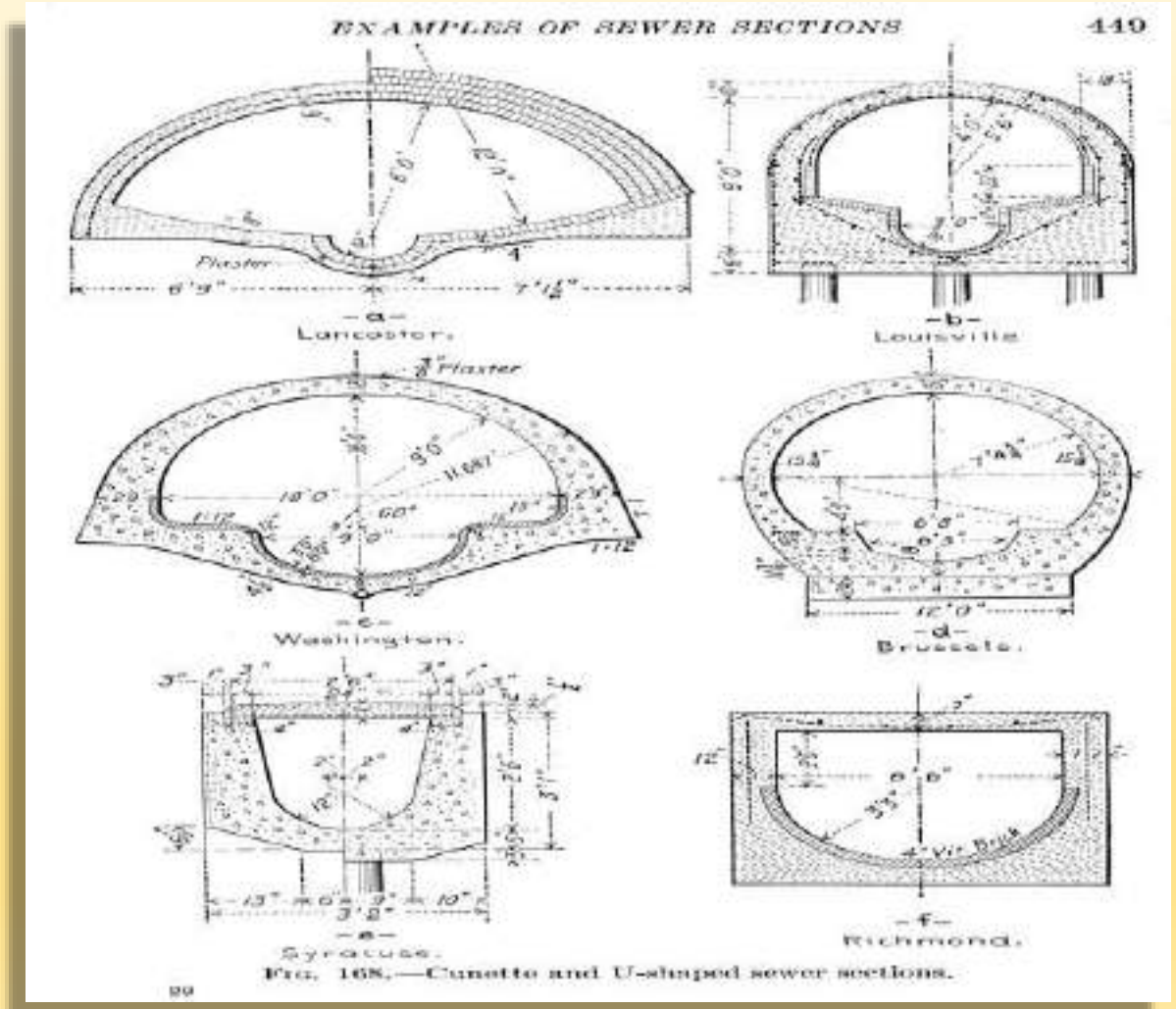


FIG. 168.—Cunette and U-shaped sewer sections.

Sewer Sections

Egg Shaped Sewer

- The Depth of These sewers is one and half times of their width In older form it was Used with greater radius at bottom, but in new form smaller radius is used at the bottom. These types of sewer section are mostly used because in dry weather. Self cleaning velocities is available at greater depth of water as compared with other sections. These sections are always constructed at the Site.
- This section is most suitable for combined system, because it gives self cleaning velocity even in D.W.F. This section can be equally suitable for separate system, because it will easily accommodate the flow of sewage with the development of the town. It has good hydraulic properties, even better than circular section with low discharges
- The only disadvantage is that its construction is difficult and it is less stable than circular section.

Sewer Sections

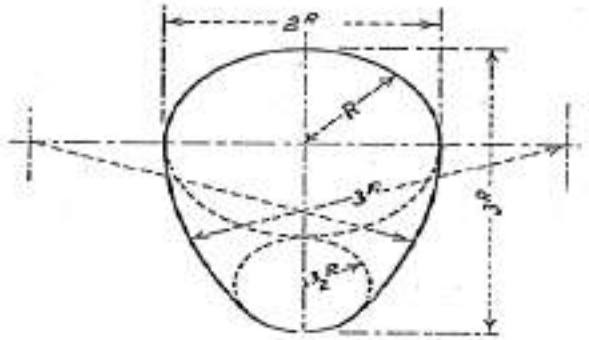


FIG. 2.—Standard Egg-shaped Section for Brick Sewer.

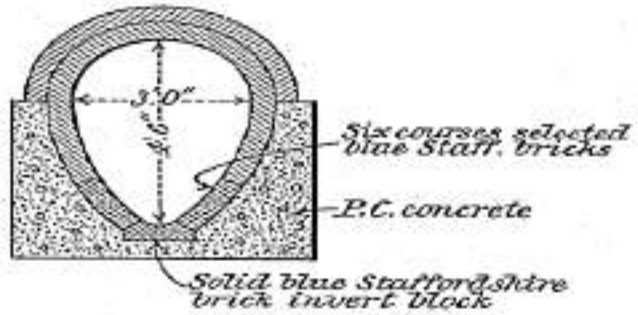


FIG. 4.—Main Sewer, Southampton.

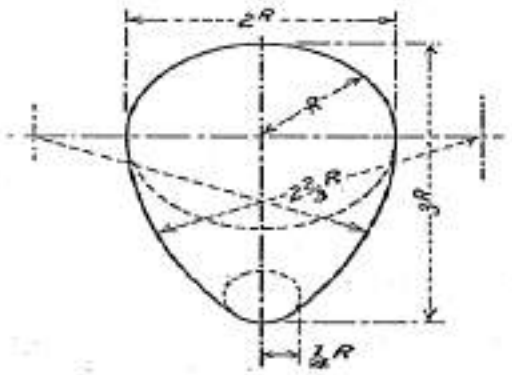


FIG. 3.—New Type of Section for Brick Sewers suited for both Small and Large Flows.

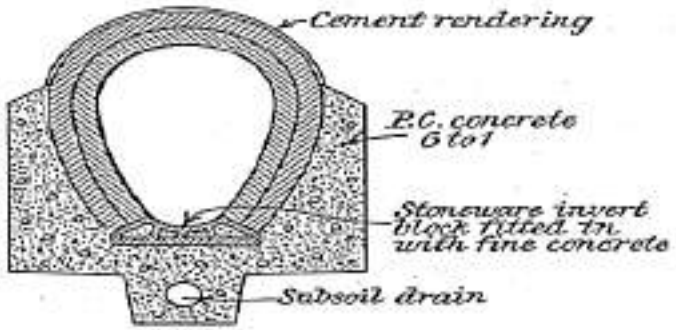


FIG. 5.—Section of Egg-shaped Sewer, showing use of Invert Block and Subsoil Drain.

Sewer Joints

- Circular Sewer pipes which are manufactured in factories are joined after placing in proper position. This type of joint depends on the material of pipe, internal pressure, external loads, types of supports and so many other factors.
- The following are the requirement of good sewer joints
- **It should be economical and easy in construction**
- **It should be water tight and highly resistant to infiltration of ground water and exfiltration of the sewage.**
- **It should be resistant to sewage gases and acids.**
- **It should be non-absorbent and should not absorb any thing.**
- **It should be durable and have long life.**
- **It should be easily available in required Quantity.**
- **It should not be easily broken or cracked by traffic.**

Sewer Joints

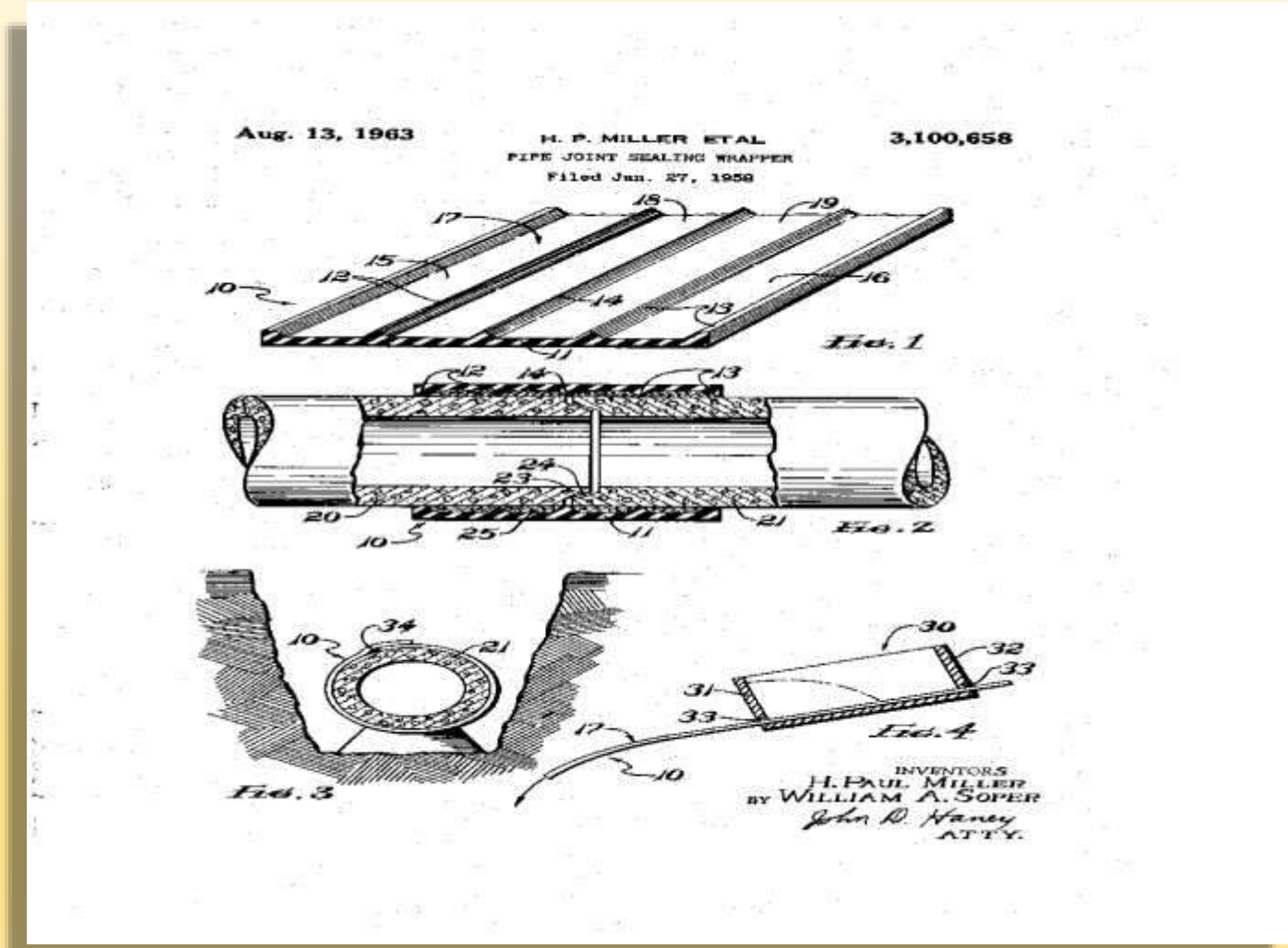
- Sewer joints are of following types
- **Bandage Joint**
- **Spigot and Socket Joint, rigid and semi flexible**
- **Collar Joint, rigid and Semi flexible**
- **Flush joint, internal and External**

Sewer Joints

Bandage Joint

- This joint is mostly used for concrete pipes. At the end of the pipe, a hollow is scooped out 25 mm deep, 75 mm under and 75 mm ahead. This hollow is filled with mortar to invert of the trench. Now netting is placed on the mortar and scrim is placed on the netting. The face of the pipe at the end are coated with mortar and are butted against each other now netting is tightly wrapped around the pipes and the strands are hooked securely together, squeezing the mortar firmly on the pipes,

Bandage Joint

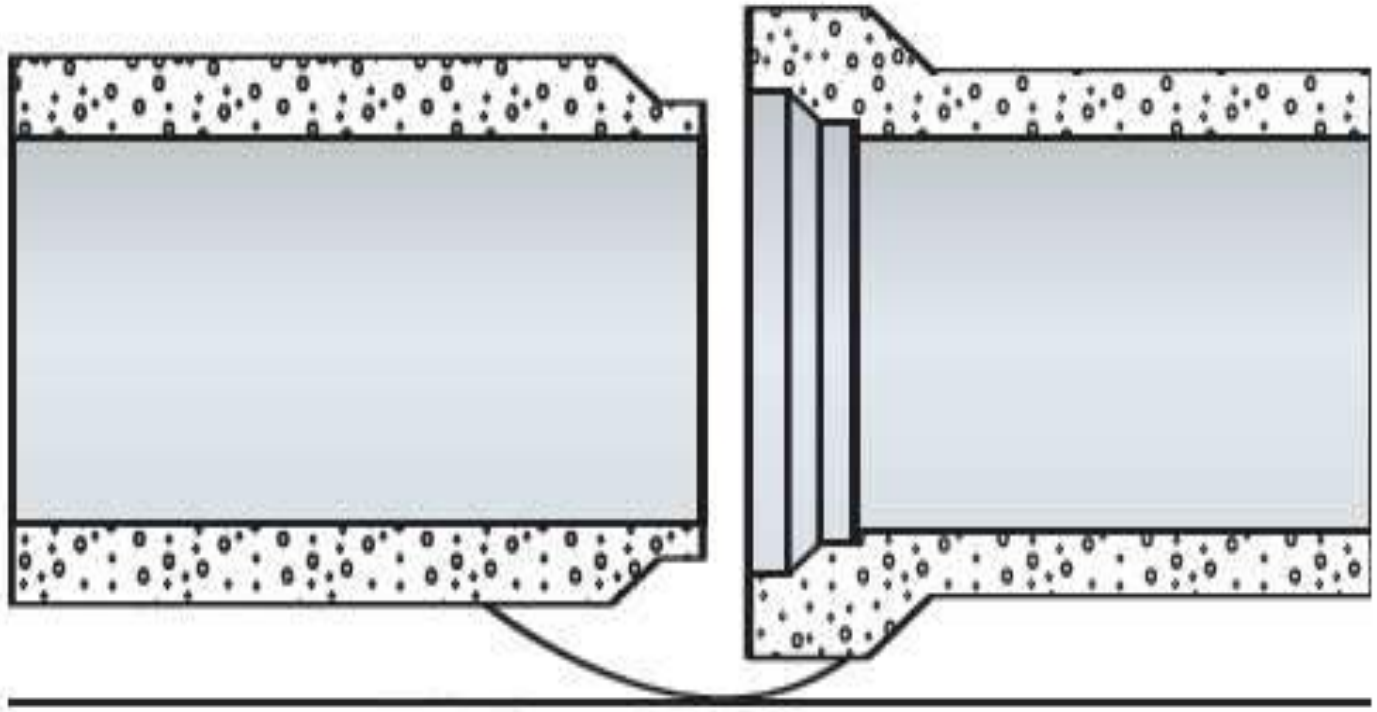


Sewer Joints

Spigot And Socket Joint

- This Joint is used mainly for cast iron pipes of all sizes and concrete pipes below 60 cm.
- Semi-flexible type spigot and socket joint is composed of specially shaped spigot and socket ends of concrete pipes. A rubber ring is placed on the spigot which is forced into the socket of the pipe previously laid. This compress the rubber ring as it rolls into the annular space formed between the two surface of the spigot and socket and forms a flexible and water tight joint.

Spigot And Socket Joint

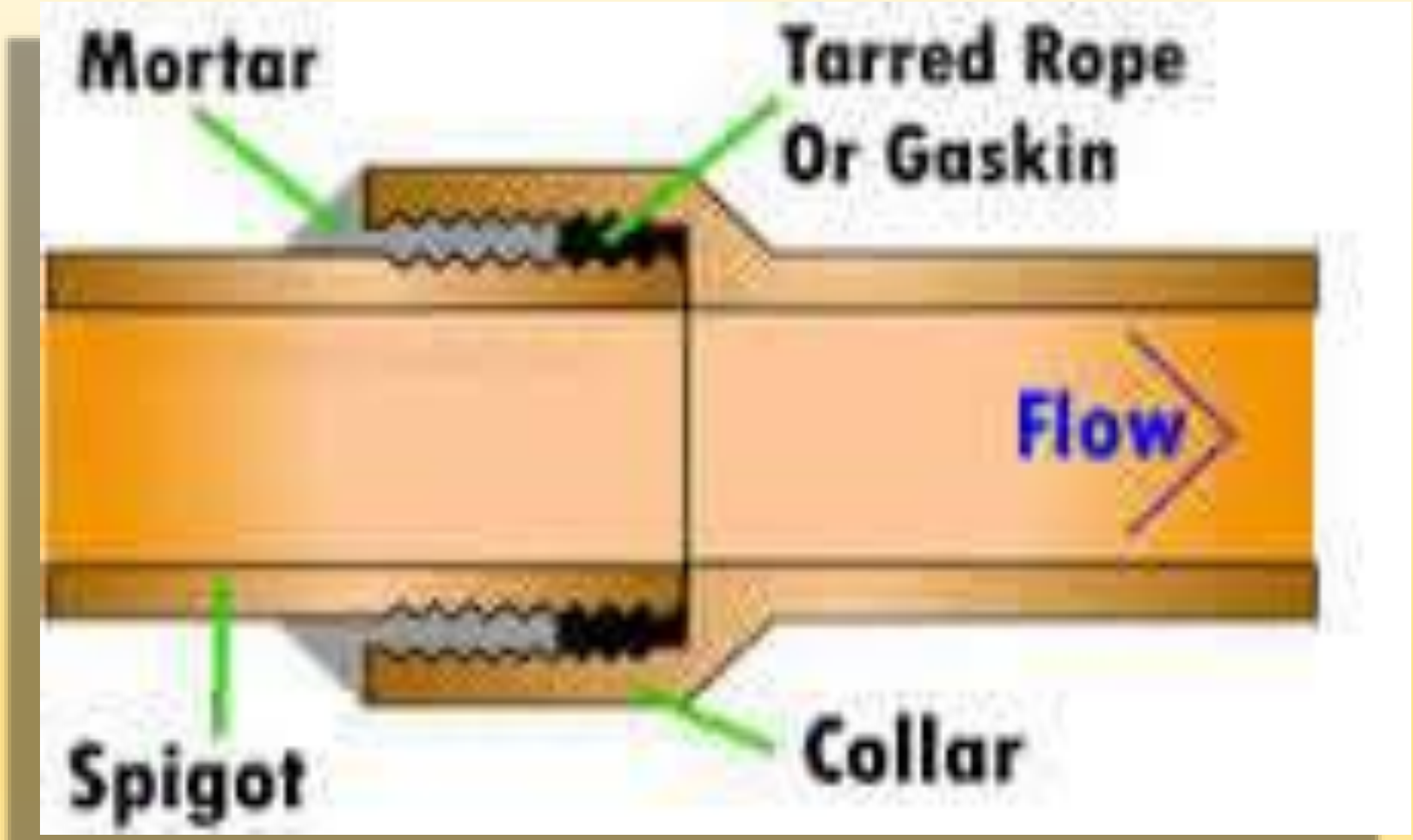


Sewer Joints

Collar Joint

- Collar Joint This is generally used for pipes over 60 cm dia and for light hydraulic pressure. Collars are 15 cm to 20 cm wide. Caulking space varies from 1.3 to 2 cm according to the diameter of pipes. Caulking material is slightly dampened mix of cement and sand rammed with caulking irons.
- **Collar Joint (Semi Flexible)**
- This is generally used for large diameter hydraulic pipes. The loose collar cover twin specially shaped pipes. Rubber rings are provided on each end which when compressed between the spigot and collar, seals the joint.

Collar Joint



Sewer Joints

Flushing Joint

- Internal flush joint is generally used for sewers passing below culverts. The ends of the pipes are specially shaped to form a self-centering joint with an internal jointing space of 1.3 cm wide. The finished joint is flush with both inside and outside with the pipe wall. Cement mortar is used for filling the jointing space.

Sewer Joints

Filled and Poured Type Joints

- In this joints the jointing is filled in plastic condition in the gap between the spigot and socket. In poured type joints the joining material is filled in liquid condition in the joint for joining the pipes.

Sewer Appurtenances

- Sewer appurtenances are the structures which are constructed at suitable interval along a sewer line. This structure helps in efficient working and maintenance of the sewerage system These structures are listed below
- Manholes
- Drop Manholes
- Lamp Holes
- Clean Outs
- Street Inlets
- Catch Basins
- Sand Grease and Oil traps
- Flushing tanks
- Inverted Siphons
- Storm Water Regulators

Manholes

Manholes

- These are masonry or RCC structures, constructed at suitable intervals along the sewer lines, for the purpose of cleaning the sewer lines. They also help in joining the sewer lines and in changing the direction or alignment as well as gradients of sewer lines. Manholes are directly constructed over the center line of sewer. Their shape in plain is circular, rectangular or square.

Manholes

Manholes

Manhole Location

- Manholes are provided at every change in alignment of sewer line, at every change in gradient of sewer lines and at every junction of two or more sewer lines.
- Manholes are also provided at head of every sewer line and wherever there is change in size of sewer manholes are provided.
- On long straight sewer lines manholes are provided at regular intervals and the spacing of manholes on such lines depends upon the size of sewers. Larger the diameter, greater is the spacing, between two manholes.

Manholes

- Manual of Sewerage and sewage treatment prepared by central public health and environmental engineering organization recommends the manhole spacing as below:

Dia of Sewer	CPHEEO recommended Spacing
0.9 to 1.5	90- 150
1.5 to 2.0	150 to 2000
More than 2.0	300

Classification of Manholes

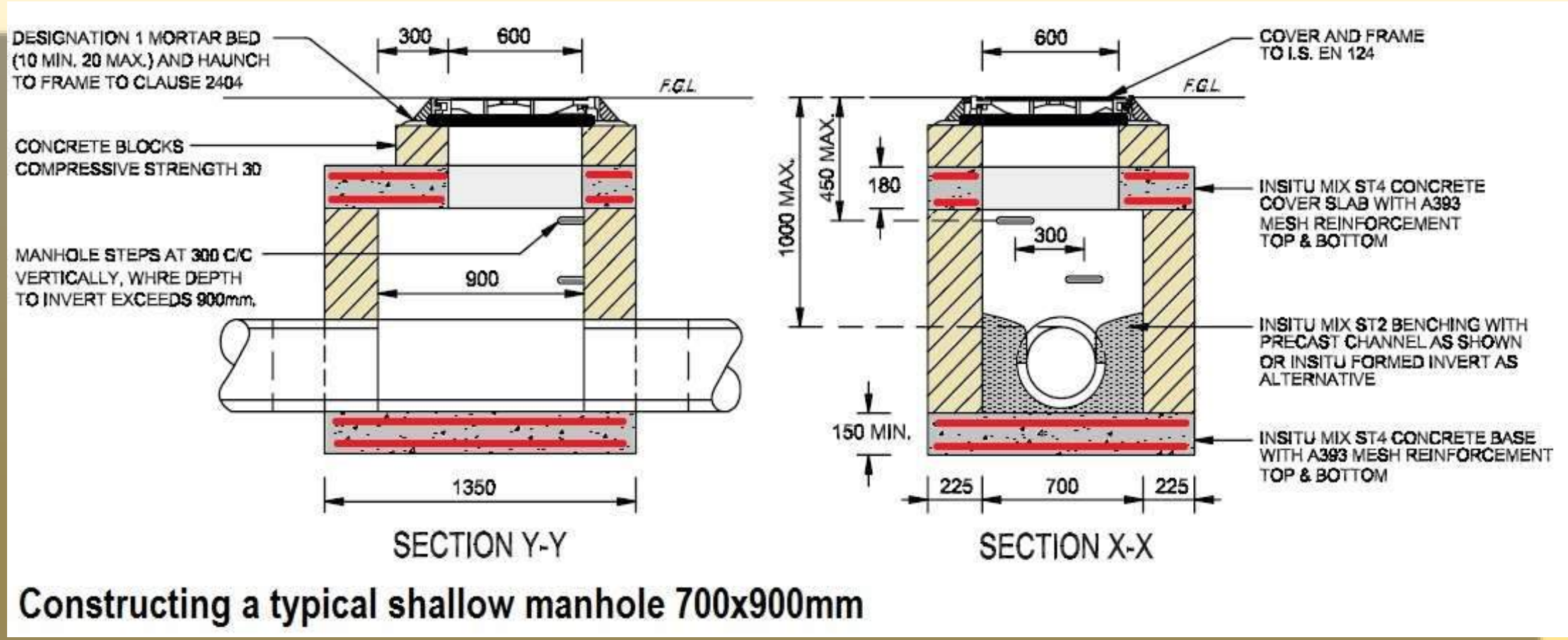
- Shallow Manholes
- Normal Manholes
- Deep Manholes

Classification of Manholes

Shallow Manholes

- They have following features
- Depth is about 0.75 to 0.9 m
- Regular Shape
- Minimum Internal Size is 0.9 m x 0.8 m
- Constructed at places where there is no heavy traffic.
- They are also known as inspection chambers.
- Light Cast Iron Cover and frame is provided at top of these manholes.

Classification of Manholes



Constructing a typical shallow manhole 700x900mm

Classification of Manholes

Normal Manhole

- They have following main features
- Depth is from 0.9 to 2.0 m
- Minimum internal size is 1m x 1 m or 1.2 m x 0.9 m for rectangular shape and minimum diameter of circular shape is 0.9 m (Internal)
- Section of square or rectangular manhole is not changed.
- Circular manholes have uniform section in lower portion and slanting at top so as to narrow down the top opening.
- Heavy Cast Iron covers and frames are provided in these manholes.

Classification of Manholes

Deep Manholes

- Their Main features are
- Depth is more than 2.0
- Internal diameter is kept as follows:

Depth	Internal Diameter
2to 2.3 m	1,2 m
2.3 to 9 m	1.5 m
9.0 to 14 m	1.8 m

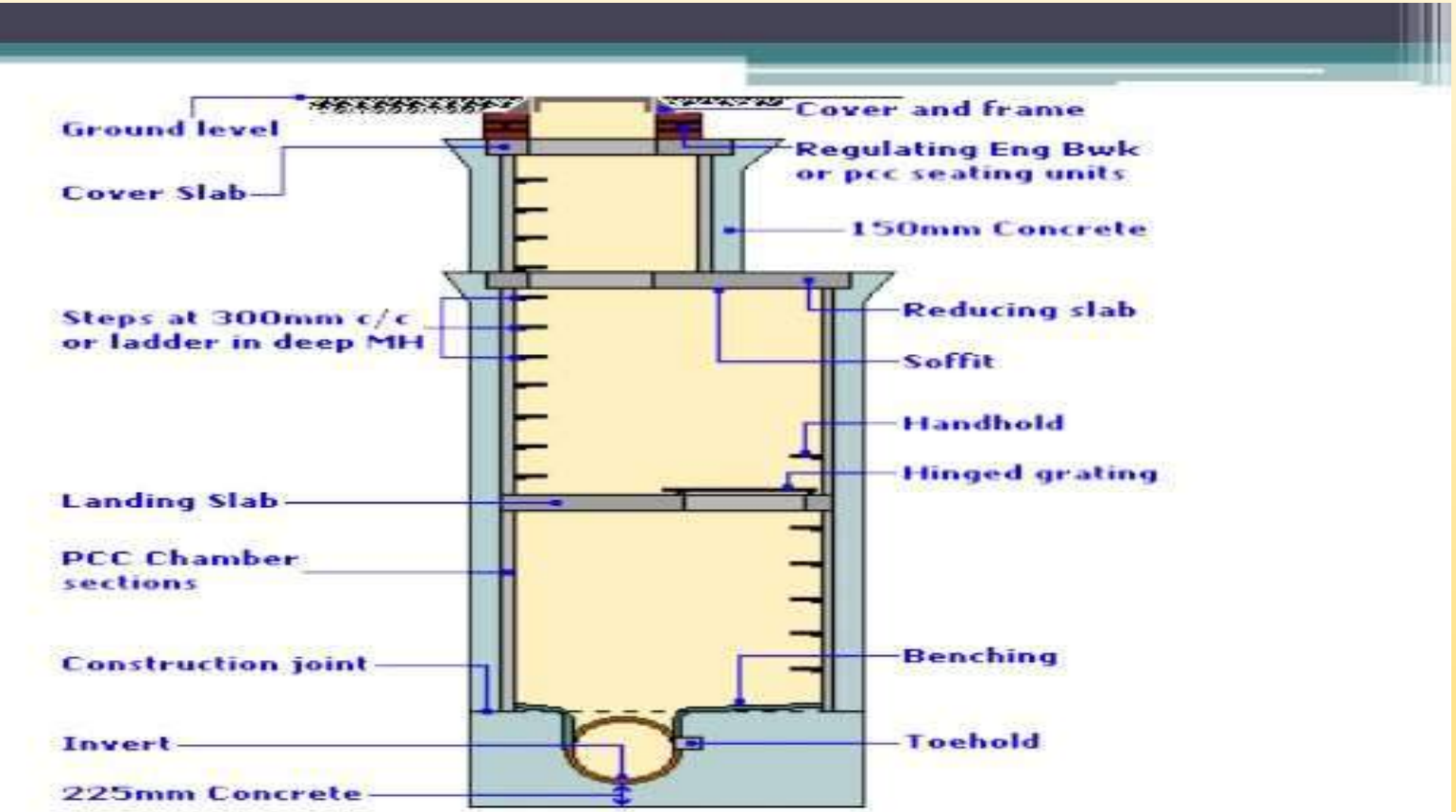
- They are provided with steps on internal surface of one wall
- Heavy Cast Iron Cover and frames are provided at top.

Components of Manholes

Following are the components of a typical Manhole

- Access Shaft
- Working Chamber
- Base and side walls
- Bottom or Invert
- Steps or Ladders
- Cover and frames

Components of Manholes



Idealized Adoptable Deep Manhole
Cross-section

Components of Manholes

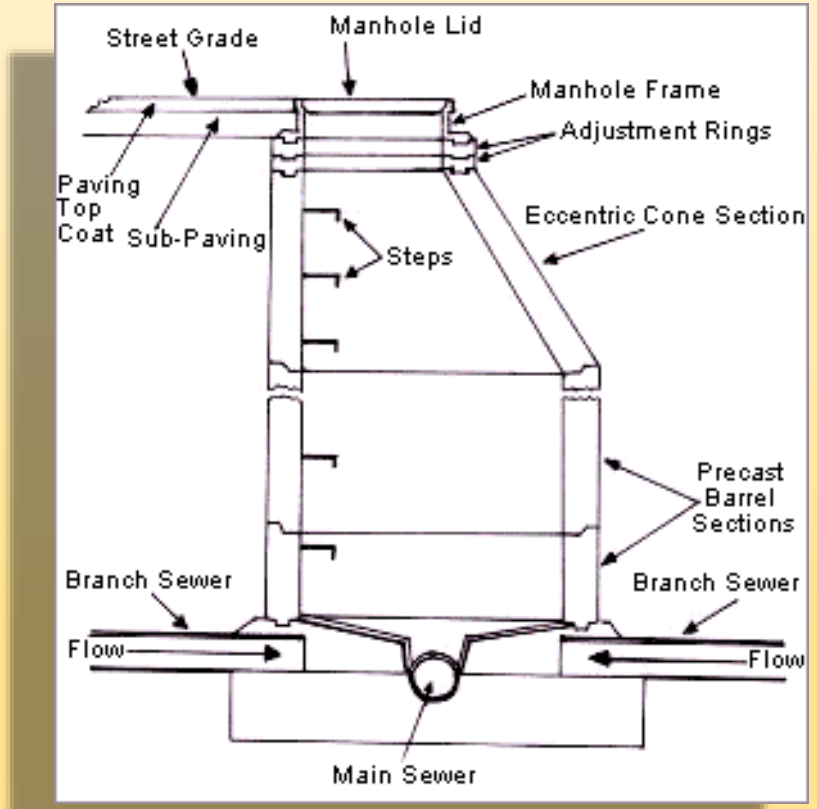
Access Shaft

- Access shaft upper portion of deep manhole is known as access shaft. It is an access to the working chamber.
- Minimum size of access for rectangular manholes is 0.75 m to 0.6 m and for circular manholes dia of access shaft is 0.7 m

Working Chamber

- Lower portion of manhole is known as working chamber which provides working space for cleaning and inspection of sewer line. The minimum size of the working chamber for deep manhole is 1.2 m x 0.9 m with larger dimension in direction of flow. For Circular manholes the minimum diameter is 1.2 . The height of the working chamber should preferably be not less than 1.8 m

Components of Manholes
Access Shaft



Components of Manholes

Base and Side Walls:

- Base of the manhole is made up of plain cement concrete bed. The plain cement concrete bed supports the side walls. Minimum thickness of concrete bed is as shown below

Sr.No	Depth of Manhole	Bed Thickness in cm
1	Upto 0.8	10
2	Above 0.8 and upto 2.1	23
3	More than 2.1	30

- The side walls of manholes are made of brick masonry or stone masonry or reinforced cement concrete.

Bottom or Invert

- A semi circular channel of cement Concrete is constructed at the bottom of manhole. The diameter of channel is equal to the diameter of sewer. Above the horizontal diameter the sides of the channel are extended vertically nearby up to the crown of the sewer. Bottom of the channel is in the same level as that o invert of sewer.
- It is necessary to enter in the manhole for inspection and cleaning of sewers in case of clogging of sewers or flooding of wastewater from manholes. To facilitate entry and exit of workers steps are provided in all manholes having depth greater than 0.8 m

Bottom or Invert

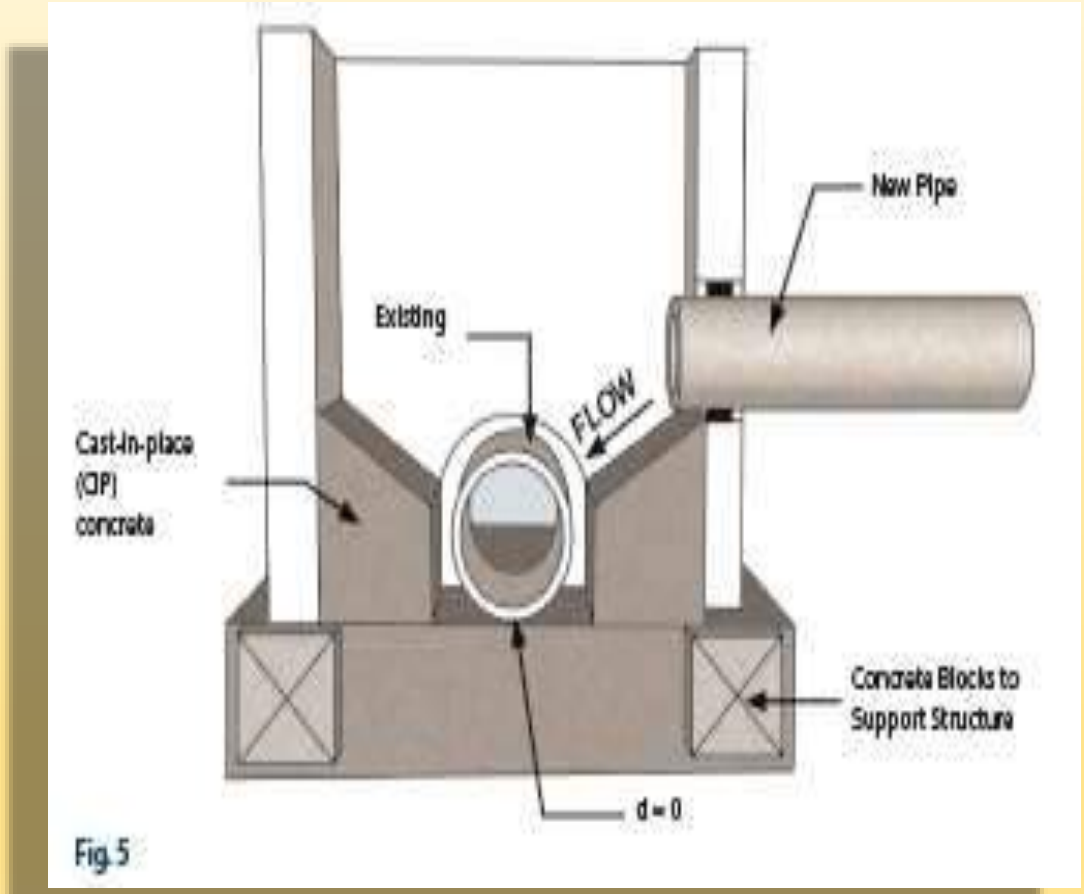
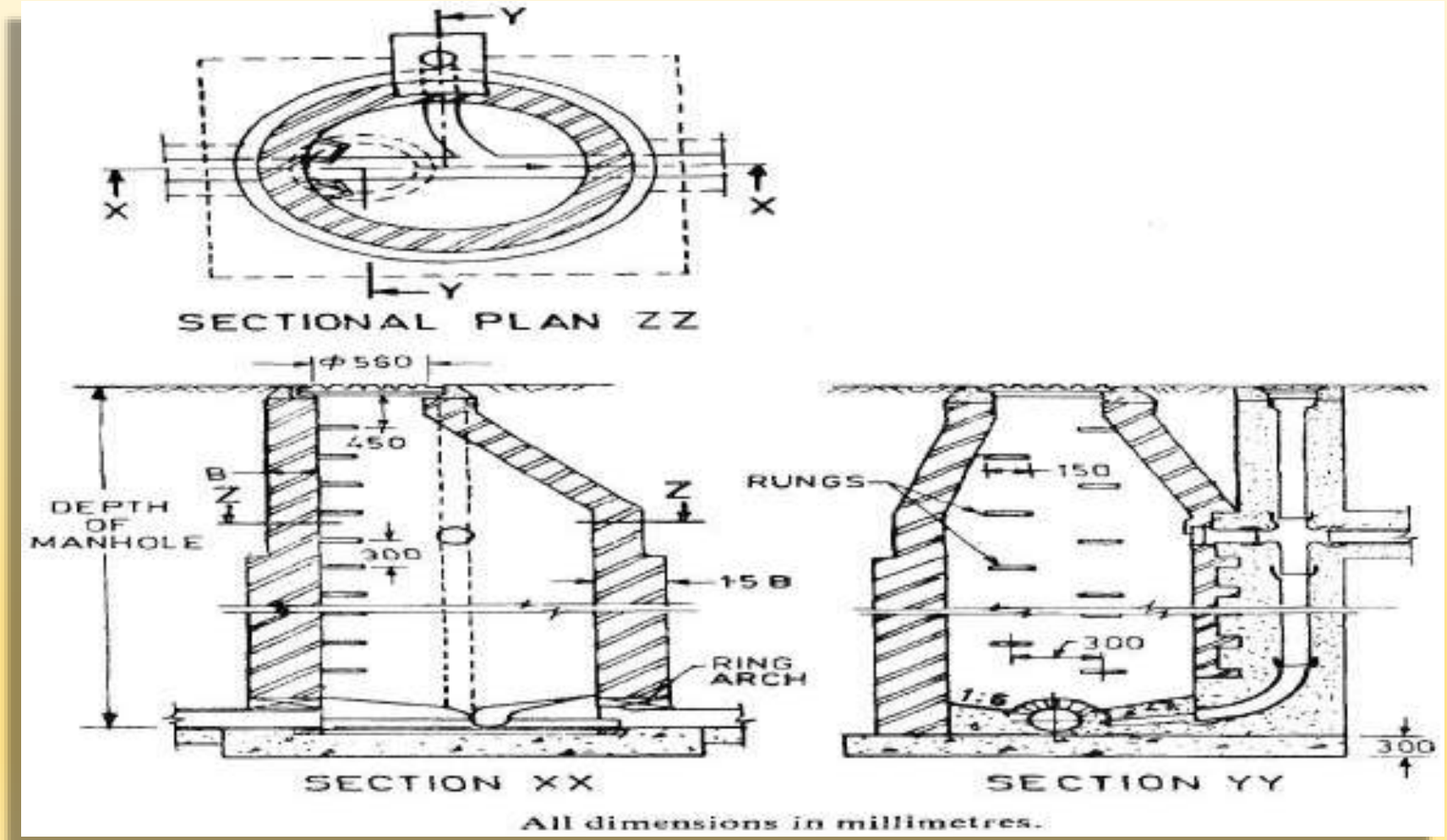


Fig. 5

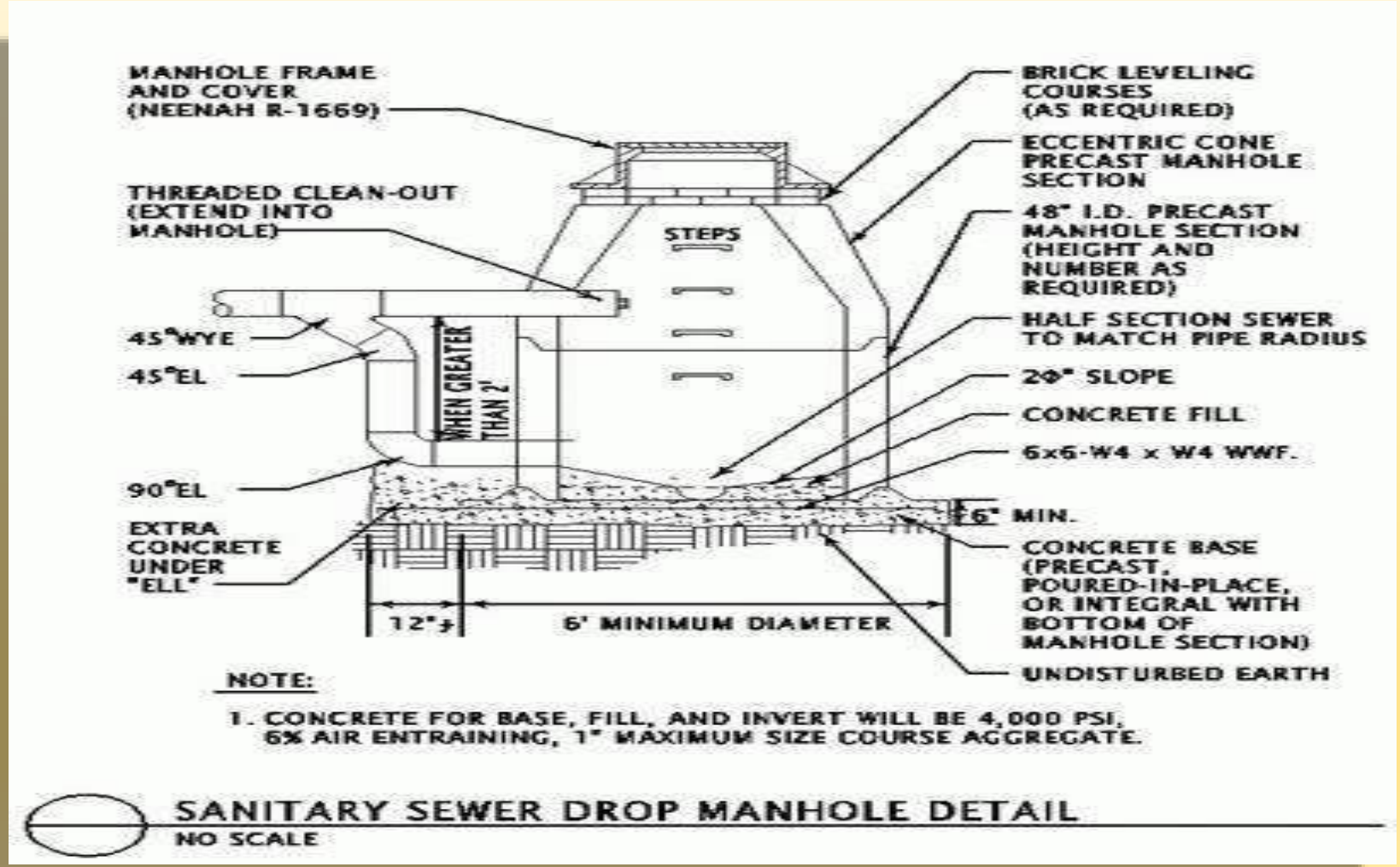
Drop Manholes

- Drop manhole is constructed where a sewer line at higher level is to be connected with a sewer line at lower level. Such a situation arise when the branch sewer at shallow depth is to be connected with main sewer at greater depth the wastewater from the branch sewer shall fall downward and such a situation is not desirable because falling wastewater shall damage the bottom of the manhole and even very very strong bottom will be required.
- When the difference between the invert level of branch sewer and peak flow level in main sewer is more than 600 mm drop manhole is provided.

Drop Manholes



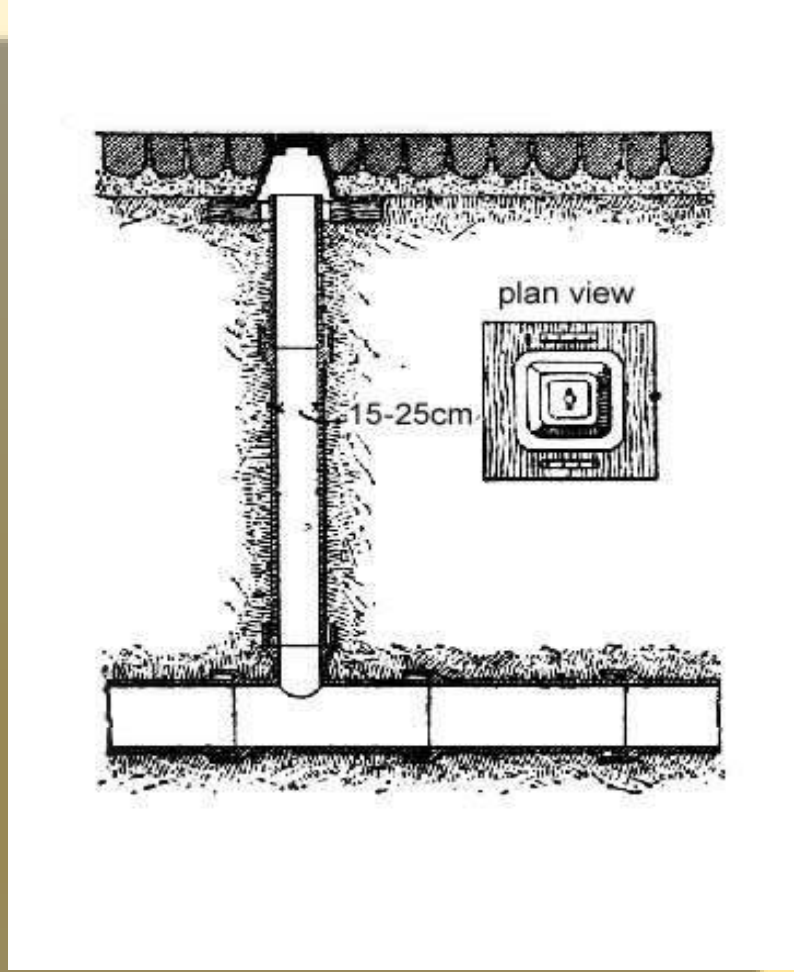
Drop Manholes



Lamp holes

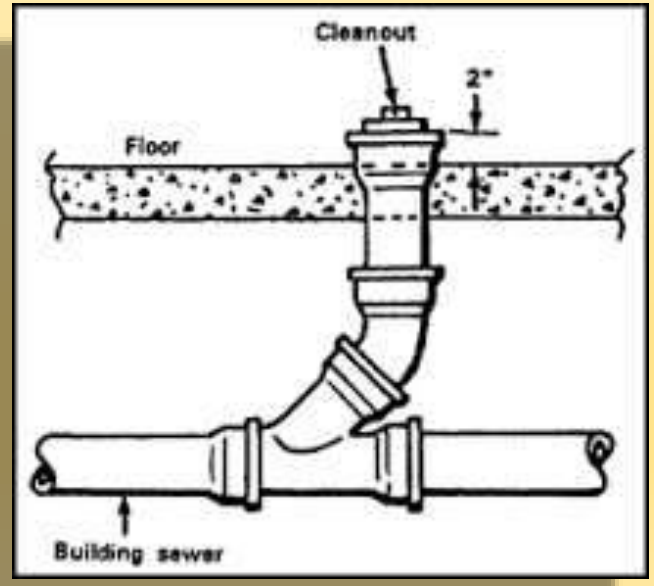
- These are provided along the sewer lines when
- **(i) There is a curve in sewer line and due to shortage of space manholes are not possible.**
- **(ii) There is change in gradient and it is not possible to construct manhole.**
- A vertical shaft is connected to the sewer by a T bend
- While inspecting lamp is inserted in lamp hole and from the manholes on both sides of lamp hole it is checked whether the light is seen or not. If sewer is chocked light will not been seen in the nearby manhole.
- Lamp hole have become obsolete and they are not recommended now a days.

Lamp holes



Clean Outs

- Clean outs are constructed in sewer lines for the purpose of facilitating cleaning of sewers.
- An inclined pipe is connected to sewer line. Through the inclined pipe the cleaning rod is inserted in sewer to clean the sewer.



Street Inlets

- For Collection of storm water street inlets are provided. Street inlets are connected with the storm sewer or a combined sewer by means of stoneware pipe of diameter **25 to 30 cm**.

Street Inlets

- Curb Inlets
- Gutter Inlet
- These inlets are directly placed below the road and at the top of the catch basin bar screen or precast RCC perforated covers are placed. Through the perforated RCC cover water enters in the catch basin and reaches the sewer.

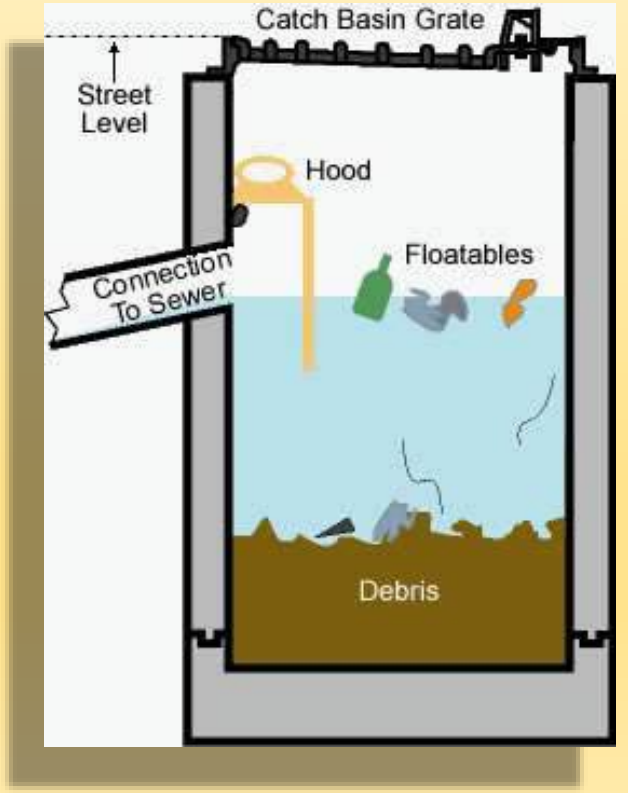
Street Inlets

Combined Inlets

- In combined Inlet the storm water enters from the top as well as side of the catch pit

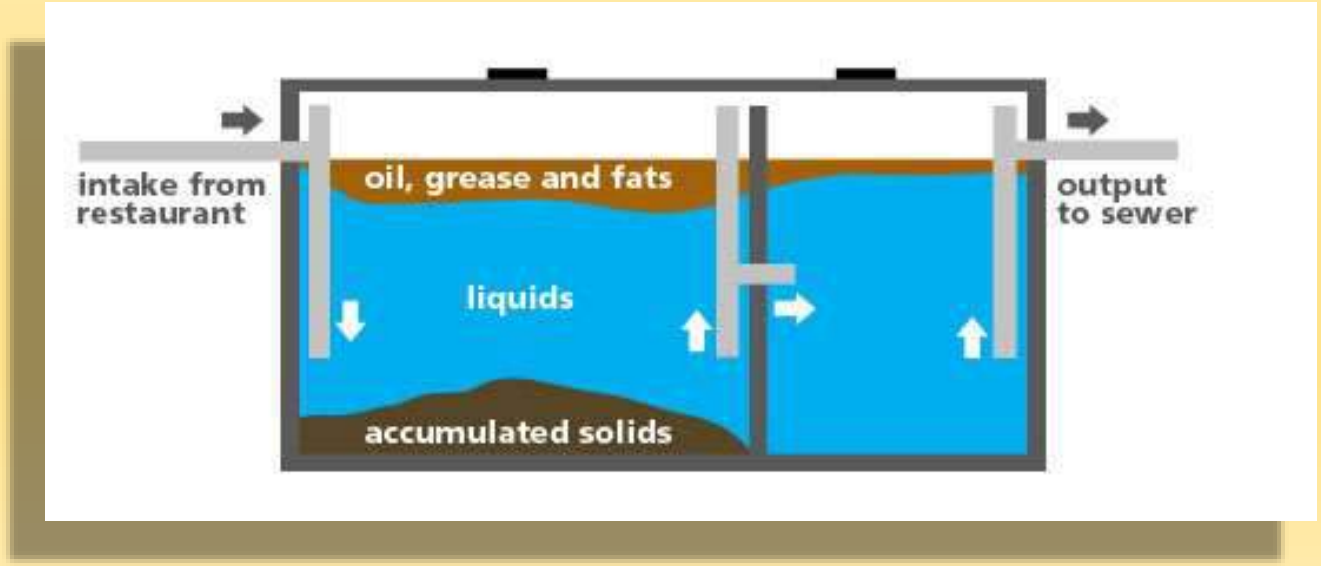
Catch Basin

- These are special types of inlets. Here the size of the pit is larger and sufficient volume is kept for grit and sand particles to settle and deposit at the bottom of the pit.



Sand Grease and Oil Traps

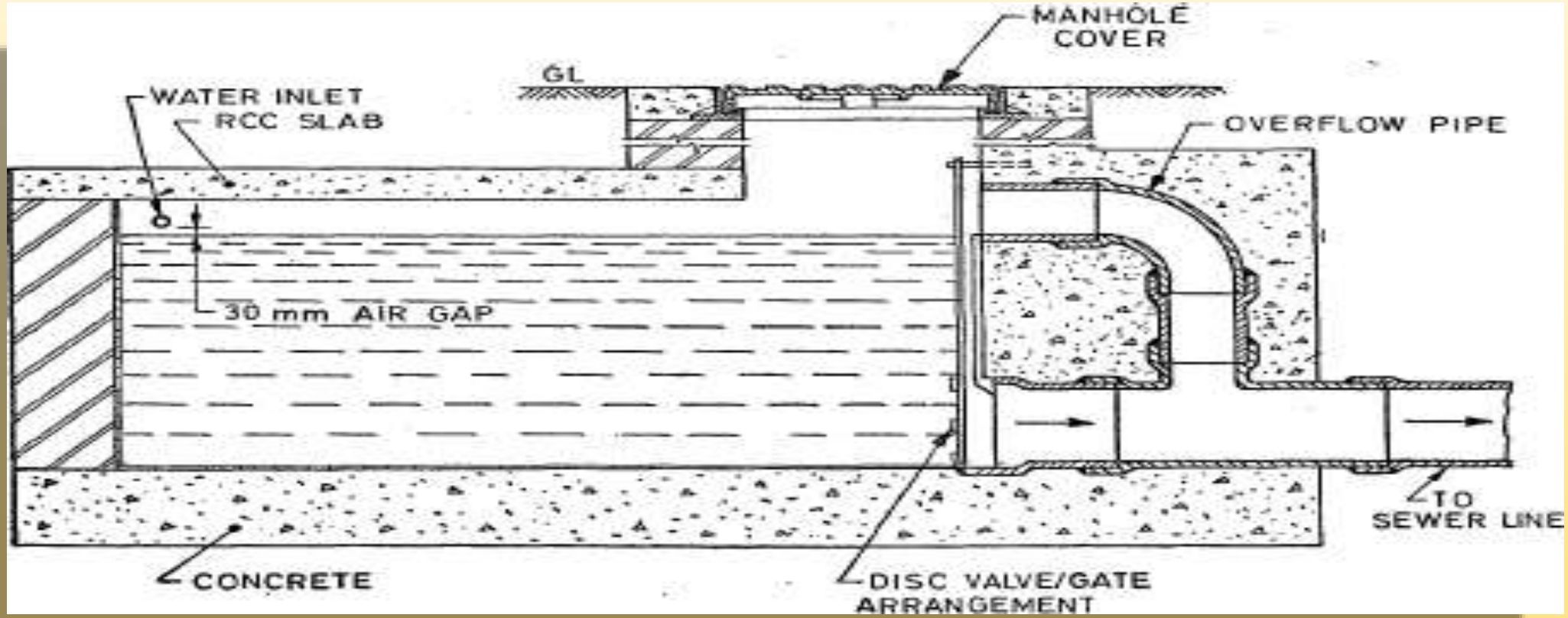
- Wastewater from hotels, restaurants, kitchens and industries contain grease, oils and fats which is required to be removed before wastewater enters in sewer line. If oil grease etc.. are not removed it will stick to the surface of sewer and become hard and obstruct the wastewater flow



Flushing Tanks

- These tanks are provided for storing water and then flushing it. These tanks are located at the dead end of the sewer. The capacity of the flushing tank depends upon the diameter of the sewer to be flushed.
- Flushing tanks are of two types
- Manually Operated flushing Tanks are not used nowadays
- Automatically operated flushing tank
- It consists of a masonry or concrete chamber. A water inlet pipe is provided in chamber to fill it with water. A U tube with a bell cap at its one end connects the chamber with sewer, where water is filled in chamber it will enter in the bell also. As soon as water level rises to a certain level siphonic action takes place. The capacity of these tanks is around 900 to 1400 liters and it is adjusted in such a way that it works twice a day depending upon the size of sewer and quantity of deposits in sewer.

Flushing Tanks



Inverted Siphons

- Inverted Siphons are normally provided when the sewer line has to cross an obstacle like roadway, railway etc.. In the inverted siphon hydraulic gradient line is above the flow line, whereas in true siphons the gradient line is below flow line. Inverted siphone are also known as depressed sewers.
- The pipes of inverted siphons must be able to withstand internal pressure. The diameter of pipe should be such that flow velocity is non silting. High velocities are not obtained in very large sewers carrying very low flow of sewage. It is therefore required to provide three pipes in parallel and separated with lateral weirs. It is recommended that the siphons should have a velocity of 0.9 m/sec even at minimum discharge of wastewater.

Inverted Siphons

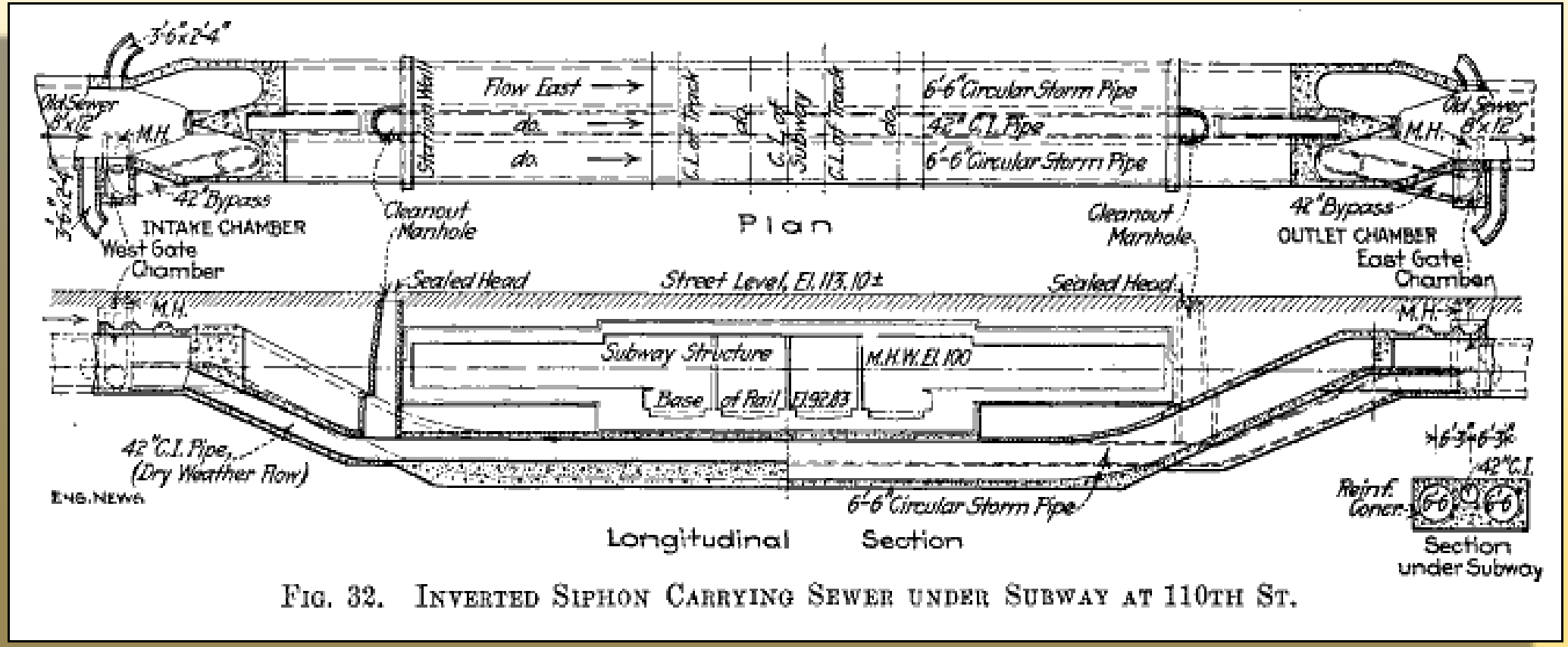


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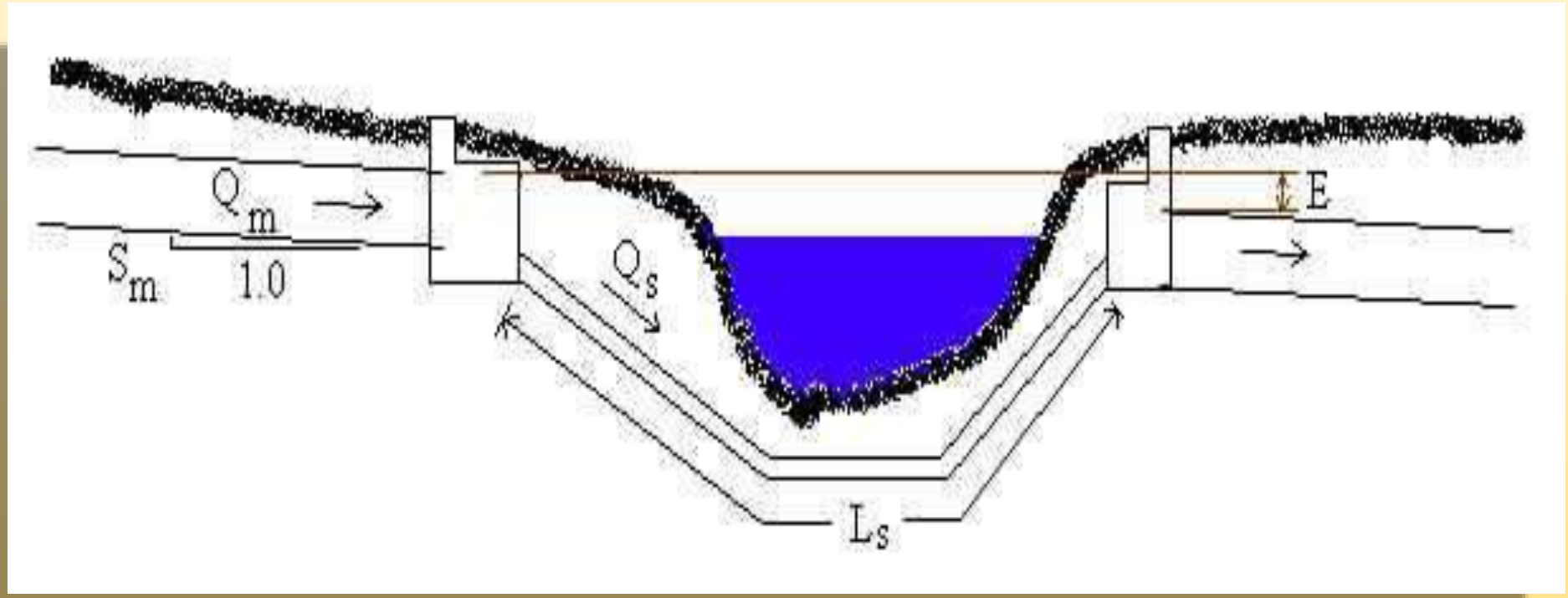
FIG. 32. INVERTED SIPHON CARRYING SEWER UNDER SUBWAY AT 110TH ST.

Storm Water Regulators

- These are Constructed in combined sewerage system and their function is to divert the excess storm water into nearby stream. Sewers are designed to carry the peak flow sometimes because of the excess rainfall storm water to be disposed in excessive and capacity of sewer is not sufficient for its rapid disposal.
- **Storm water regulator are of three types:**
- **Leaping Weir**
- It consists of an opening in the invert of the combined sewer, therefore which normal storm flow is diverted to the intercepting sewer. The excess flow leaps over the combined sewer to flow in to nearby stream

Storm Water Regulators



Overflow Diversion through Pipe

- Openings at the suitable heights above the invert of sewer are made at suitable interval along the length of the combined sewer. These openings are joined to the storm water drain pipe for disposal by it to the stream.

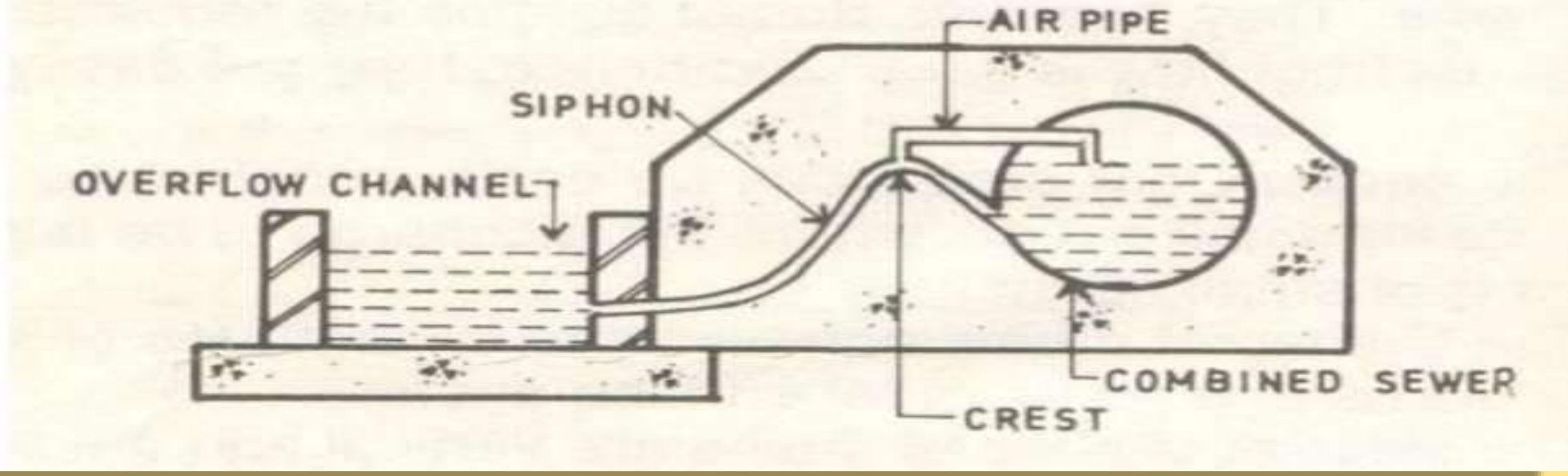
Siphon Spillway

- Siphon spillway arrangement for storm water relief. This method provides most effective type of storm water relief work. It is automatic and works on principle of siphonic action. Siphonic action starts where the level of wastewater rises in sewer beyond the crest level of the siphon. The level of crest is kept at the level reached by the maximum wastewater flow in dry weather. Thus siphonic action is not taking place at the time of maximum flow in dry weather. When wastewater level in the sewer increases crest level, wastewater enters in the siphon and mouth of air pipe is sealed and wastewater flow starts in the siphon pipe. When wastewater level reduces and becomes lower than crest level air from the sewer enters the air pipe and prevents the siphonic action.

Siphon Spillway

Regulators

- Siphon Spillway – This is an automatic arrangement and works on the principle of siphonic action.



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Prof A M Malek
Mahajan Publishing House

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Thanks

GHT

INTRODUCTION

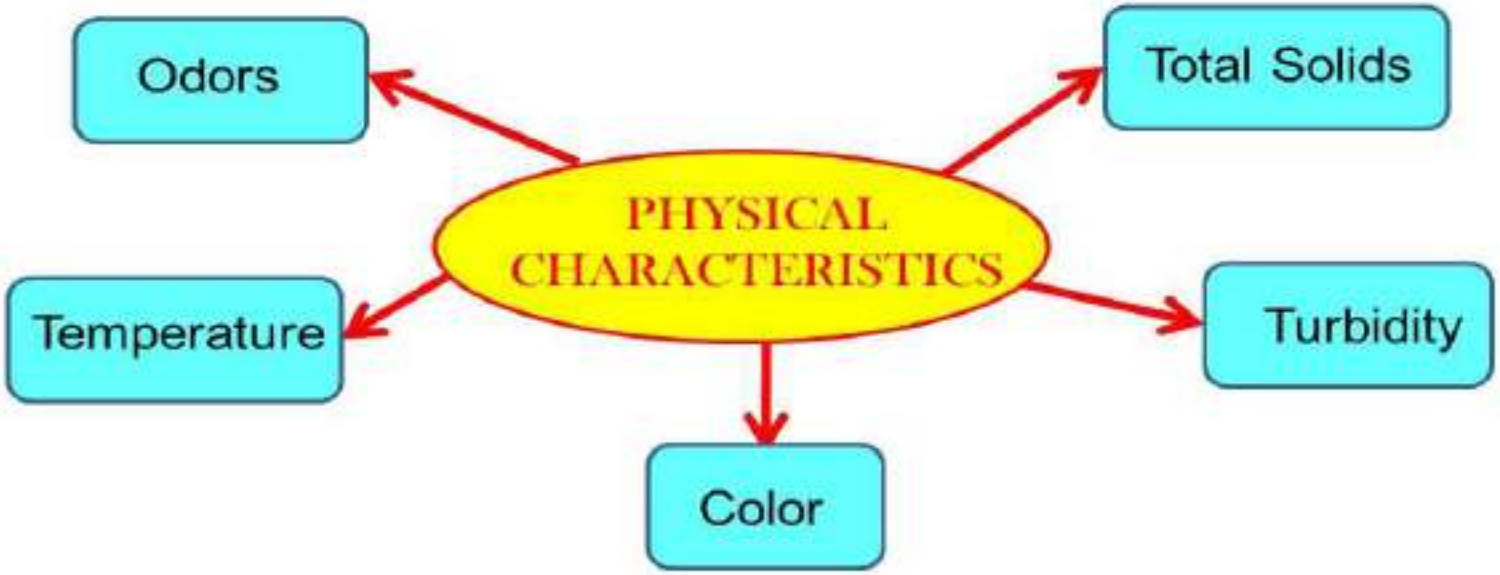
- Sewage consists of various residential, public and industrial mixtures of wastewater, which contain organic and inorganic materials in dissolved or suspended or colloidal form as well as various microorganisms useful and harmful to human life.
- We need the characteristics and examination of sewage before designing any sewage treatment system to work efficiently.

Characteristics OF SEWAGE / Waste water

- The Characteristics of sewage arc classified as follows:

1. Physical characteristics
2. Chemical characteristics and
3. Biological characteristics

1. Physical characteristics



A . **Color :**

Color is due to the suspended and other matters found in wastewater.

If sewage is fresh it has a soap solution color i.e **grey-brown** and decomposed sewage has **dark grey color**.

B. Odour:

Fresh sewage is of **soapy or oily odour** but stale sewage has **offensive odour due to H_2S, CH_4**

- **C. Temperature:**

Generally sewage has slightly higher temperature than the water which increases the biological activities. 40 degree C.

D . Turbidity :

It is very turbid than water due to the presence of high suspended and other

E. Solids : 350-1200 mg/L

- Though sewerage typically contains lower than zero to 0.5 % solids, the remainder being water, still the nuisance caused by the solids cannot be unnoted, as these solids are extremely degradable and so want correct disposal.
- The sewerage solids could also be classified into dissolved solids, suspended solids and volatile suspended solids.

- Data of the volatile or organic fraction of solid, that decomposes, becomes necessary, as this constitutes the load on biological treatment units or resources of a stream once sewerage is disposed off by dilution.

- The estimation of suspended solids, each organic and inorganic, provides a general image of the load on deposit and grit removal system throughout sewerage treatment. Dissolved inorganic fraction is to be thought-about once sewerage is employed for land irrigation or the other utilize is planned.

2. Chemical Characteristics

- Sewage contains complex compounds derived from urine, faces, inorganic chemicals etc.

- **a. pH**
- **b.** DO (Dissolved Oxygen)
- **c.** BOD (Biochemical Oxygen Demand)
- **d**. COD (Chemical Oxygen Demand)

- **a. pH**
- The hydrogen ion concentration expressed as pH scale, could be a valuable parameter within the operation of biological units.
- The pH scale of the contemporary sewerage is slightly quite the water provided to the community. However, decomposition of organic matter might lower the pH scale, whereas the presence of business waste material might manufacture extreme fluctuations typically **the pH scale of raw sewerage is within the vary 5 to 8.0**.

- **DO (Dissolved Oxygen):**

  It is the amount of oxygen dissolved in waste water. Presence it indicates the sewage is fresh or oxidation has been occurred after treatment. It is necessary to ensure at least 4 ppm of DO in stream in which treated wastewater is disposed otherwise fish are likely to be killed.

- **BOD (Biochemical Oxygen Demand)**

  BOD is defined as the amount of oxygen required for the bacteria to oxidize the *organic* matter present in the sewage.

BOD – 80 mg/L

- **COD (Chemical Oxygen Demand)**

- It is defined as the amount of oxygen required for chemical oxidation of organic matters readily oxidizable carbonaceous and other matter.
- **COD – 150 mg/L**

Item	Raw Feed Water	Reclaimed Water
pH (−)	7.1	6.3
Degree of Transparency(cm)	28	＞100
Turbidity (degree)	16.1	＜0.1
Odor	faint offensive as sewage	out of analysis
Color (degree)	23.5	＜0.1
Coriform Group Bacteria (number/100mℓ)	2,200	out of analysis
Heterotrophic Plate Count (number/100mℓ)	33,000	out of analysis
BOD (mg/ℓ)	7.9	＜0.5
COD (mg/ℓ)	25.0	＜0.5
SS (mg/ℓ)	6	0.0
T-N (mg/ℓ)	40.5	11.3
NH_4-N (mg/ℓ)	33.5	7.8
T-P (mg/ℓ)	3.8	＜0.005
MBAS(Substance Causing Foam) (mg/ℓ)	0.16	＜0.01

3. Biological characteristics

- Domestic sewage consists of various types of plant or animal microorganism and the biological characteristic of sewage is related to the presence of these microorganisms.
- This microorganism whose presence is 22 — 25 millions numbers in a liter of sewage may be pathogenic, indicator organisms etc. The main source of pathogenic microorganism is excreta from sick people and these organisms require living tissues to grow and reproduce and harmful to man.

The microorganism can be broadly classified into:

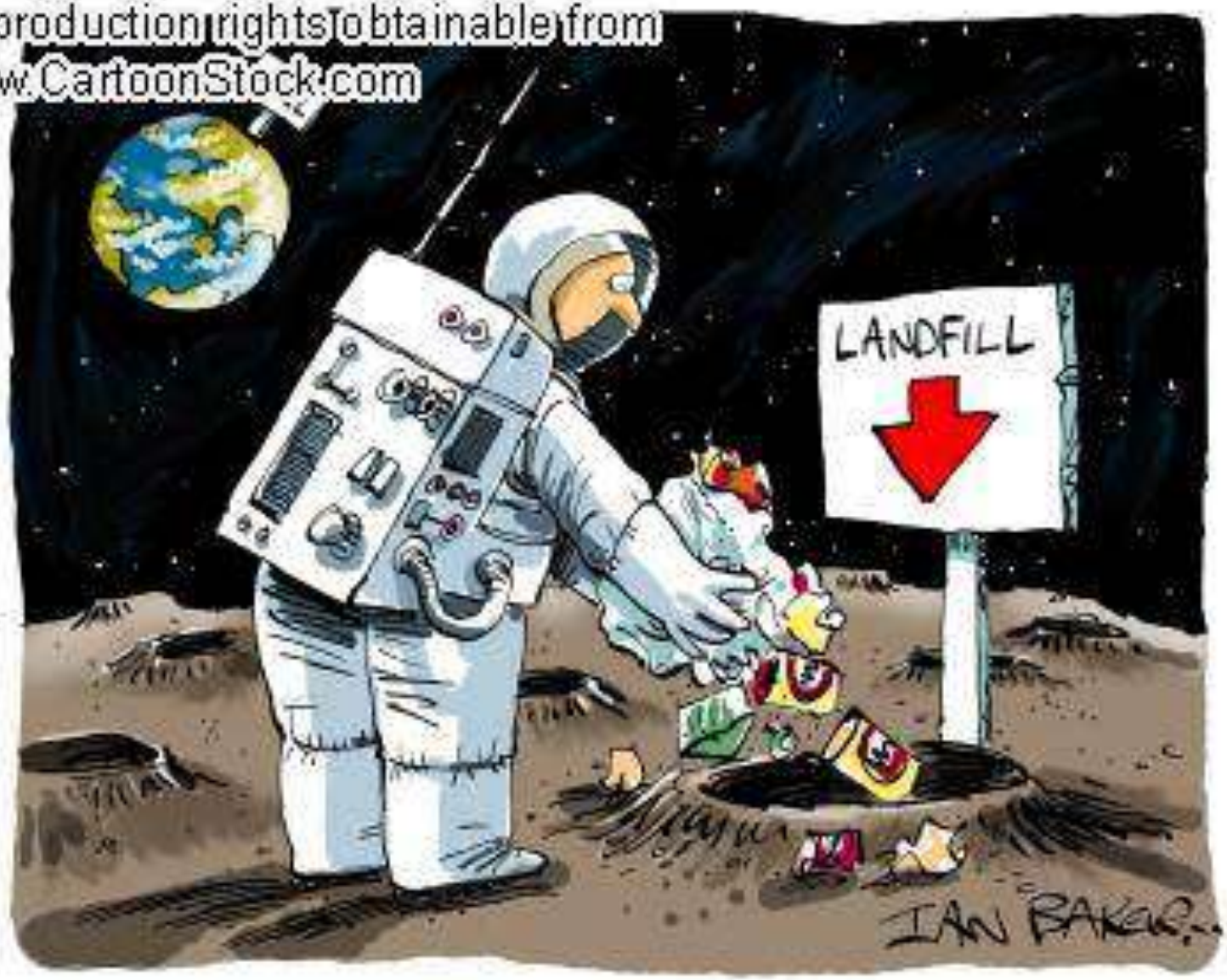
- (a) Aquatic plants
- (b) Aquatic animals
- (c) Aquatic mold (fungi), bacteria and virus.

- Aquatic Plants consists of waterweeds algae etc.
- Aquatic animals consist of fish, snails, amphibians insects, earth Worms, hydra etc.
- *Aquatic* mold (fungi), bacteria and virus are also aquatic plant but categorized separately. These are responsible for disease.

- The bacterium which needs **free oxygen to survive** is called aerobic bacteria and which **survives without free oxygen** is called anaerobic bacteria and which **survives in presence or absence of free oxygen** is called facultative bacteria.
- The decomposition of sewage is possible due to these bacteria.

Land Disposal of waste and Environmental Pollution.


www.seppo.net
HISTORICAL MONUMENT
Mount Landfill
OOOOOH!
ONCE UPON A TIME PEOPLE USED TO DUMP HERE ALL THEIR WASTE!



Land disposal

- Land disposal can be either in or on the ground—in a landfill, injection well, or other land-based unit.
- Currently, about 23 million tons of hazardous waste are land disposed each year in the world.

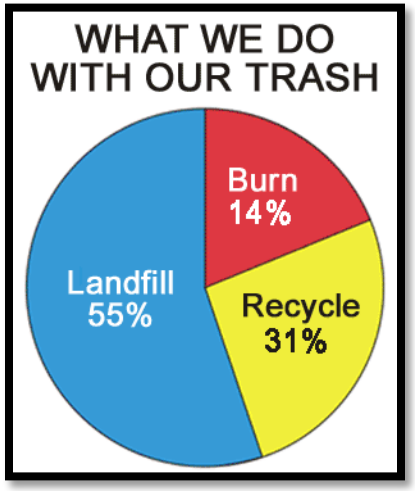
- A wide range of wastes and by-products of industrial processes is being spread on the land in agriculture, forestry and land reclamation operations.

Types of waste.

- Animal manures
- Waste from food and drinks preparation (sugar beet processing, meat and fish processing, dairies, vegetable processing, breweries)
- Blood and gut contents from abattoir
- Waste lime from cement manufacture or gas processing
- Waste from basic organic chemical and pharmaceutical companies
- Paper waste sludge, waste paper and de-inked paper pulp
- Sludge from potable water production
- Decarbonatation sludge from industries
- Dredging
- Waste from the leather and tannery industry
- Slag from steel industry
- Sewage
- Municipals waste

Disposal Methods.

- Selecting a disposal method depends almost entirely on costs, which in turn are likely to reflect local circumstances.
  - Land fill.
  - Waste buried in soil.

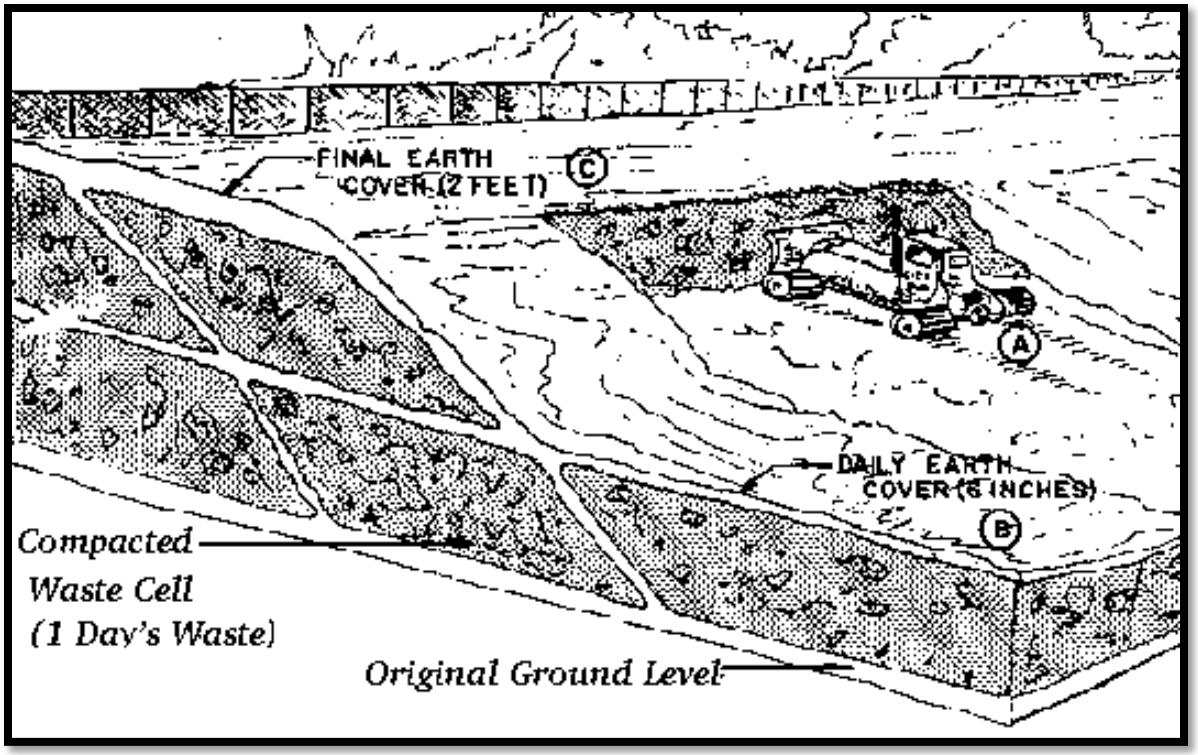


Landfill.

- **Disposal of solid wastes on land** is by far the **most common method** in most of the countries and probably accounts for more than 90 percent of the world's municipal refuse.

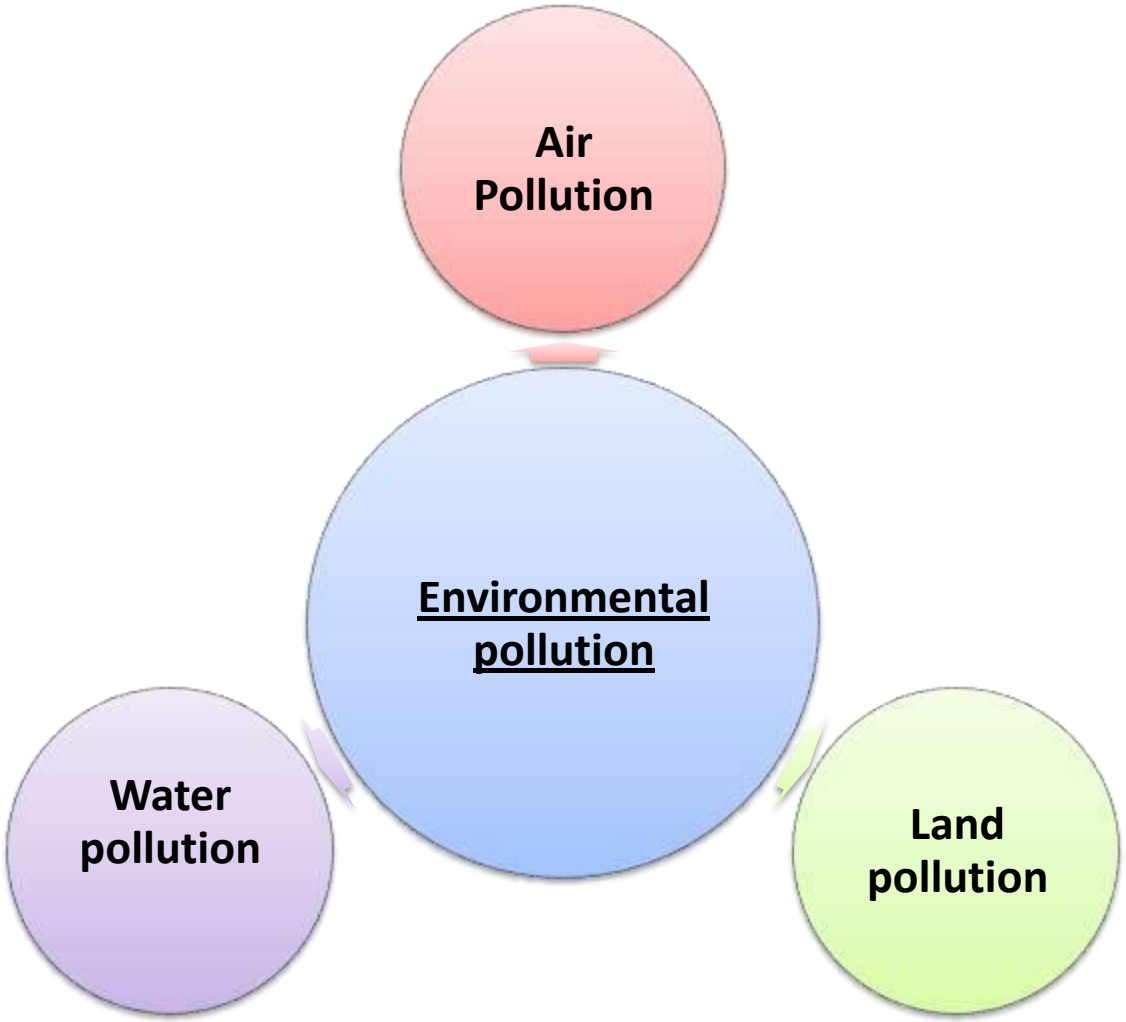
- **Sanitary landfill is the cheapest satisfactory means of disposal**, but only if suitable land is within economic range of the source of the wastes; typically, collection and transportation account for 75% of the total cost of solid waste management.

- In a modern landfill, refuse is spread in thin layers, each of which is compacted by a bulldozer before the next is spread. When about 3 m (about 10 ft) of refuse has been laid down, it is covered by a thin layer of clean earth, which also is compacted.


FINAL EARTH
COVER (2 FEET)
C
A
DAILY EARTH
COVER (6 INCHES)
B
Compacted
Waste Cell
(1 Day's Waste)
Original Ground Level

Bluemandle garbage disposal

Issues related to landfill



Air pollution

- Gases are generated in landfills through anaerobic decomposition of organic solid waste produce bad odor. If a significant amount of methane is present, it may be explosive & greatly involve to green house effect.
- People who lives near those sites may suffer with respiratory disorders occurring with toxic gases, dust, and fumes.
- When pollutants get mixed with air, this causes acid rain. Acid rain degrades the top soil.

Water pollution

- Rain can penetrate and pass through hazardous waste and can leach out and carry hazardous organic chemicals & inorganic chemicals such as heavy metals into the groundwater as well as near by surface water sources.
- People those who utilize the ground water or the surface water will absolutely expose to those pollutants and severe health problems may occur.
- Also elements such as N, P, leaching to surface water sources will be create eutrophication conditions.
- That will increase the biological oxygen demand of water sources and cause to reduce the bio diversity of water source. Such places become big environmental and social problems.

Land pollution

- land wasting damages microbial population and other soil fauna by releasing various toxic substances & disturbing their normal habitats.
- Garbage dumping, specially plastics, reduce the soil fertility as they are non biodegradable.
- These waste change the soil texture and prepare artificial environment inside the soil.
- This will disturbs root movement of trees and habitats of the soil fauna.

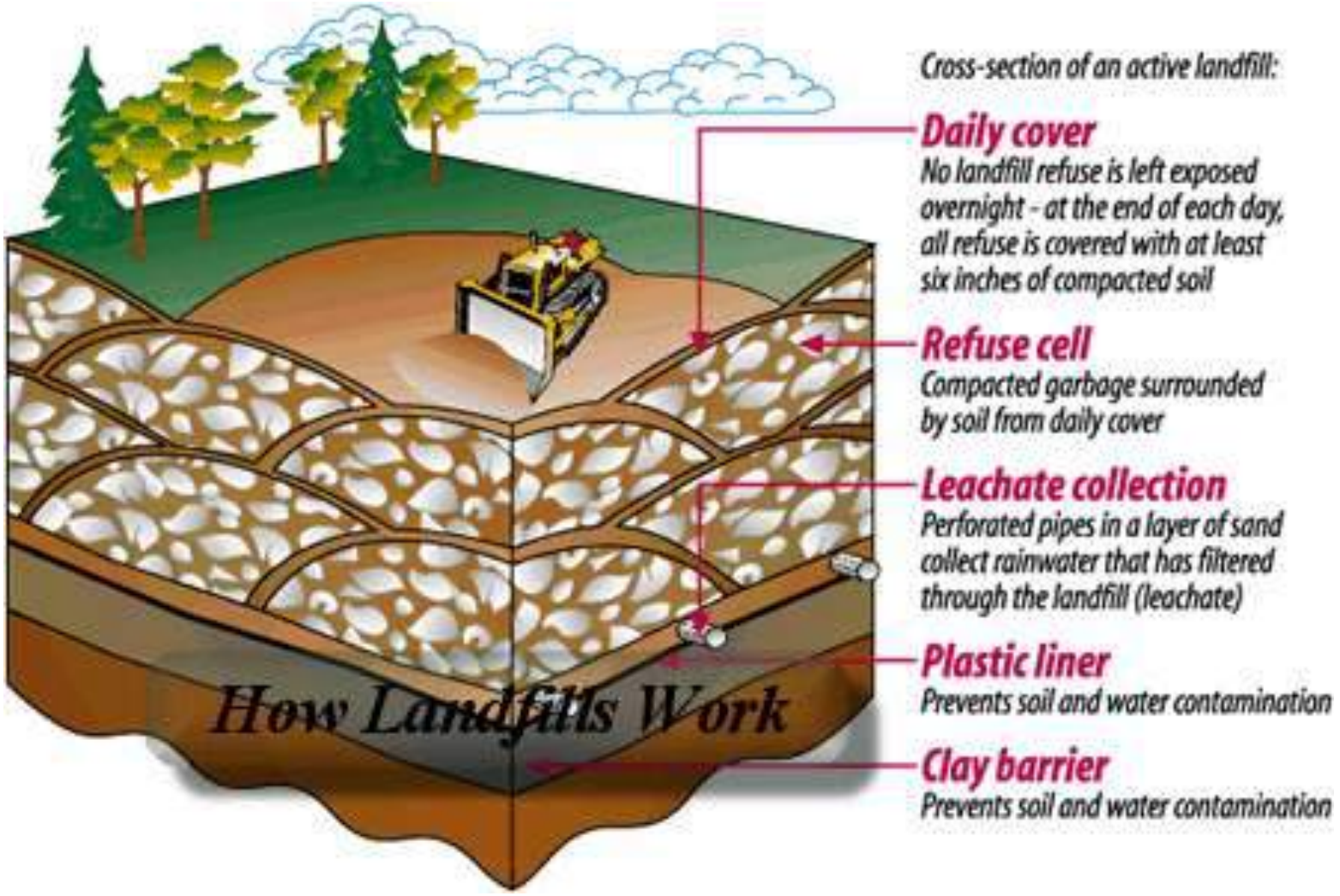
Other problems……

- health threat to people
- decaying wastes also attract household pests and result in urban areas becoming unhealthy, dirty, and unsightly places to reside in
- damage to terrestrial organisms
- reducing the uses of the land for other, more useful purposes.

- Unpleasant odor when garbage is transported.
- **Breeding of mosquito and flies** due to landfill .
- Loss in property value.
- Unpleasant odor due to landfill site.
- Arising of dust when garbage vehicles are going.
- Deterioration of road conditions.
- Increase in floods during the rainy season.
- **Radio active Nuclear waste** buried in the soil is highly hazardous and can be effect to severe health and environmental problems.

Solutions……

1. **Pollution of surface and groundwater is minimized by**
   - lining and contouring the fill,
   - compacting and planting the cover
   - selecting proper soil,
   - diverting upland drainage, placing wastes in sites not subject to flooding or high groundwater levels.


How Landfills Work
Cross-section of an active landfill:
Daily cover
No landfill refuse is left exposed overnight - at the end of each day, all refuse is covered with at least six inches of compacted soil
Refuse cell
Compacted garbage surrounded by soil from daily cover
Leachate collection
Perforated pipes in a layer of sand collect rainwater that has filtered through the landfill (leachate)
Plastic liner
Prevents soil and water contamination
Clay barrier
Prevents soil and water contamination

2. Recycling

- The practice of recycling solid waste is an ancient one. Today, recyclable materials are recovered from municipal refuse by a number of methods, including **shredding, magnetic separation of metals, air classification that separates light and heavy fractions, screening, and washing.** Those screened material are rec
various processes.

Modern municipal waste Recycling plant

3.Pulping process

- Incoming refuse is mixed with water and ground into a slurry in the wet pulper, which resembles a large kitchen disposal unit.
- Large pieces of metal and other non-pulpable materials are pulled out by a magnetic device before the slurry from the pulper is loaded into a centrifuge called a liquid cyclone.
- Here the heavier non-combustibles, such as glass, metals, and ceramics, are separated out and sent on to a glass- and metal-recovery system; other, lighter materials go to a paper-fiber-recovery system.
- The final residue is either incinerated or is used as landfill

4.Composting.

- It is most appropriate to use in household scale by allowing biodegradation of biodegradable organic materials in household waste using proper separation of waste.
- Final product can be used as a fertilizer.

5. Onsite treatment and utilization of waste should be practiced.
6. Generation of socially desirable goal on waste minimization.
7. Wastes that have severe risks and excessive problems in disposal should be identified and those which cannot be neutralized may need to be restricted at the point of creation or entry.

8. With proper management and application, liquid waste can be a resource (fertilizer,source of moisture) rather than becoming a pollutant.

9. Provide good awareness to public about proper waste disposal & management systems.

10. Provide Employment opportunities in waste disposal or sewage treatment.

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- http://www.rail-reg.gov.uk/server/show/nav.150
- http://en.wikipedia.org/wiki/Land_pollution
- http://www.sjp.ac.lk/research/pdf/10-03-Nilanthi-Bandara-environ-impacts-waste.pdf
- http://www.epa.gov/osw/hazard/index.htm
- http://www.environment.gov.sk.ca/adx/aspx/adxGetMedia.aspx?DocID=963d3581-7fc3-4797-ac75-dce206b5d61b&MediaID=1428&Filename=Liquid+Domestic+Waste+Disposal.pdf&l=English

Thank you…

Our Team

AERATION

Aeration is the process of bringing water and air into close contact in order to remove dissolved gases, such as carbon dioxide, and to oxidize dissolved metals such as iron. It can also be used to remove volatile organic chemicals (VOC) in the water.

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

Why We Use Aeration

- Oxidation of organic matter
- To increase dissolved oxygen content
- To reduce the concentration of taste and odor causing substances, such as hydrogen sulfide and various organic compounds, by volatilization / stripping or oxidation
- To oxidize iron and manganese, rendering them insoluble
- Flocculation of colloids in sewage influent
- To remove those compounds that may in some way interfere with or add to the cost of subsequent water treatment

HOW AERATION REMOVES OR MODIFIES CONSTITUENTS

- Sweeping or scrubbing action caused by the turbulence of water and air mixing together.
- Oxidizing certain metals and gases

DISCUSSION OF CHEMICAL SUBSTANCES AFFECTED BY AERATION

- Volatile organic chemicals, such as benzene, found in gasoline, or trichloroethylene, dichloroethylene etc
- Carbon dioxide
- • Hydrogen sulfide (rotten-egg odor)
- • Methane (flammable)
- • Iron (will stain clothes and fixtures)
- • Manganese (black stains)
- Various chemicals causing taste and odor

METHODS OF AERATION

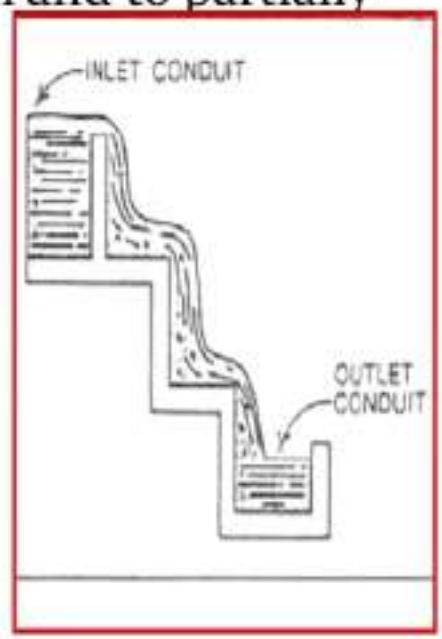
- Passing water through air

- Passing air through water

- Water can be exposed to air by spraying or by distributing it in such a way that small particles or thin sheets of water come in contact with the air.
- Water can also aerated by pumping large volumes of air through the water.

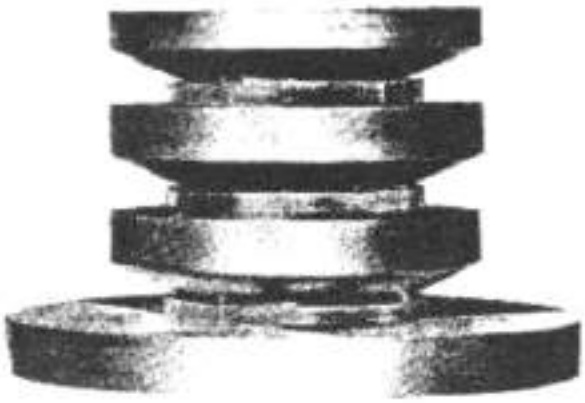
WATER INTO AIR

- **Cascade Aerators**
- A cascade aerator consists of a series of steps that the water flows over. In all cascade aerators, aeration is accomplished in the splash zones.
- Cascade aerators can be used to oxidize iron and to partially reduce dissolved gases.



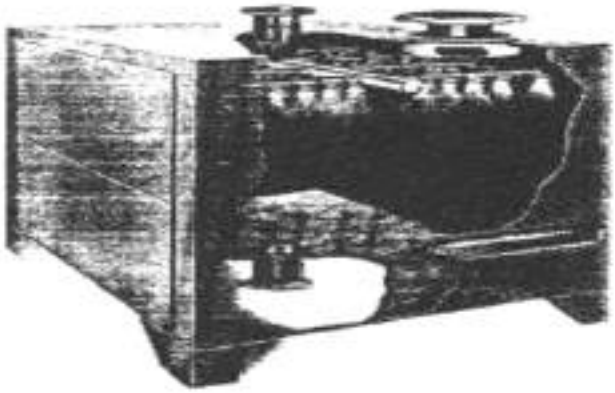
Cone Aerators

- Cone aerators are used primarily to oxidize iron and manganese from the ferrous state to the ferric state prior to filtration. The water being pumped to the top of the cones and then being allowed to cascade down through the aerator.



Spray Aerators

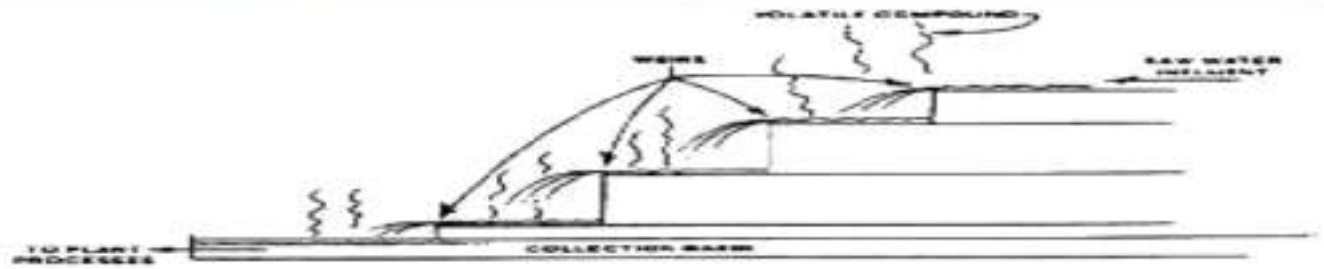
- This type of aerator has one or more spray nozzles connected to a pipe manifold. Moving through the pipe under pressure, the water leaves each nozzle in a fine spray and falls through the surrounding air, creating a fountain affect .
- In general, spray aeration is successful in oxidizing iron and manganese

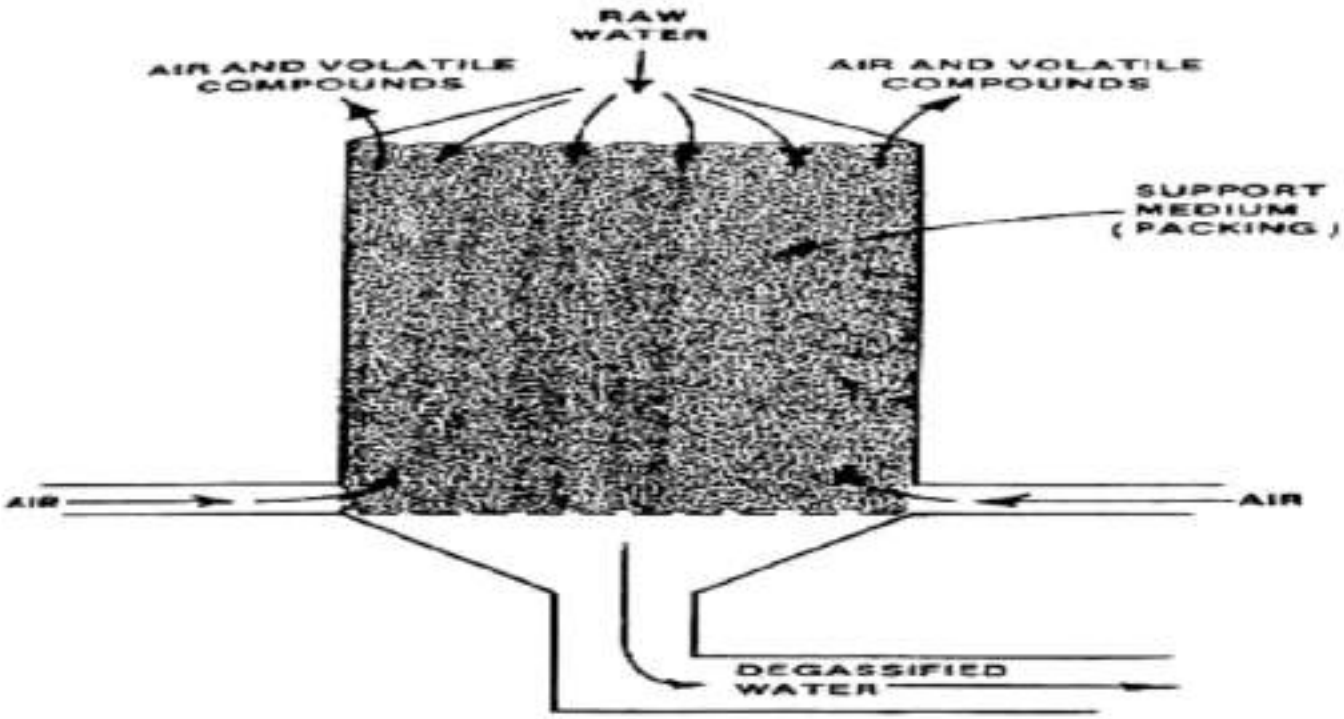


AIR INTO WATER

AIR STRIPPING

- It is quite effective in removing volatile organic chemicals (VOCs) from water.
- VOCs may be carcinogens. (eg of VOCs are benzene from gasoline and trichloroethylene from dry cleaning establishments)
- It can be accomplished by letting the water flow over cascade aerators or in specially designed air-stripping towers. In these, water is allowed to flow down over a support medium or packing contained in the tower, while air is being pumped into the bottom of the tower.





COMMON OPERATING PROBLEMS

- Super saturation(which may cause corrosion or air binding in filters)
- Slow removal of the hydrogen sulfide from the towers
- Algae production,
- Clogged filters
- Overuse of energy.

OPERATIONAL TESTING

- Three basic control tests are involved in the operation of the aeration process:
- Dissolved oxygen
- • pH
- • Temperature

TYPES OF AERATION SYSTEM

Three types aeration system are in common use:

- **Diffused air aeration**
- **Mechanical aeration**
- **Combined diffused air and mechanical aeration**

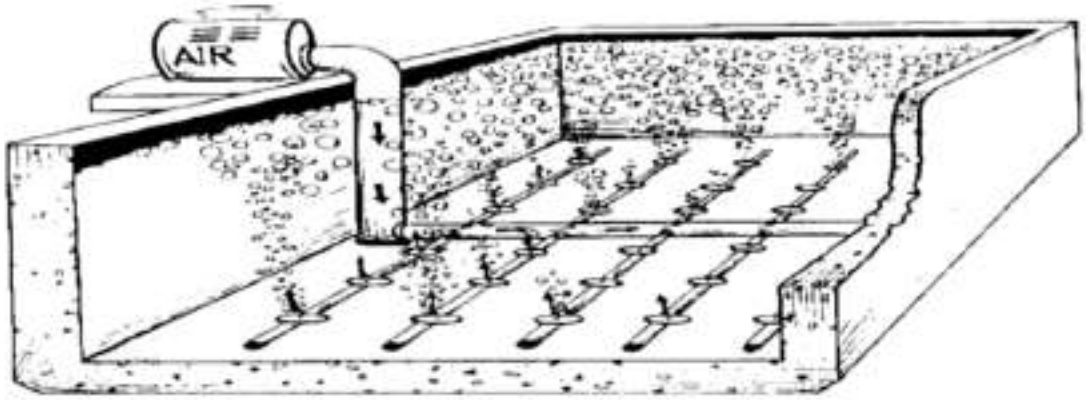
Diffuse aerators:

- A common way to aerate water is via diffused air. In these systems air is pumped through some sort of diffuser to generate small bubbles. These diffusers are porous ceramics, cloth or plastic.

- Types of diffused aeration:
  - Fine bubble
  - Coarse bubble

Efficiency of fine bubble aeration is 10 to 20 times greater than that of coarse bubble diffused aeration system

TYPICAL DIFFUSED AERATION SYSTEM:



Activated Sludge Aeration Basin

FINE BUBBLE AERATION SYSTEM:

- DIAMETRE ---- approx *2mm to 2.5 mm*
  small diameter so *more surface area* per unit volume

Coarse bubble aerators:-

They have slightly lower aeration efficiency than fine bubble aerators, but cheaper in cost and less liable to clogging and do not require filtration of air.

GUIDE FOR CHOOSING AN AERATION SYSTEM

- COST
- SERVICE CONDITIONS
- VERSATILITY
- MECHANICAL DESIGN

DIFFUSED AERATION	MECHANICAL AERATION
1. Superior Mixing □ a) full dept mixing for any depth □ b) full basin utilization	□ Limited mixing depth □ Limited energy location- poor distribution
2. Major Energy Saving □ Approx 40% energy saving vs. splash type surface aerators □ Low energy demand	□ High energy cost □ High energy demand
3. Possible Flexibility □ Can turn down or throttle entire system	□ Loss of air when unit are turn off □ No throttling possible
□4. Capital Cost □ If used in deep basin very economical □ Short payback period	□ If used in deep basin very costly □ Comparatively high payback period

ADVANTAGES OF DIFFUSED AERATION TECHNOLOGY:

1.) High oxygen transfer rate.
2.)Simple installation.
3.)Lowers energy costs.
4.Capable of bring connected to both round & square pipes.
5.)Fully flooded pipes made with eco-friendly poly-propylene.
6.)Available in usable length of up to 2 meters.

CONTENT

- OXIDATION POND ?
- TYPE OF OXIDATION PONDS
- APPLICATION OF PONDS
- AEROBIC PONDS
- ANAEROBIC PONDS
- FACULTATIVE PONDS
- ZONES OF FACULTATIVE POND
- REFERENCES

OXIDATION POND ?

- ALSO KNOWN AS STABILIZATION PONDS.

  STABILIZATION PONDS IS BIOLOGICAL TREATMENT SYSTEMS IN WHICH STABILIZATION OF ORGANIC MATERIAL IS CARRIED OUT BY BACTERIAL OXIDATION AND/OR PHOTOSYNTHETIC REDUCTION OF ALGAE.

- OXIDATION PONDS ARE USED TO TREAT SEWAGE AND BIO-DEGRADABLE INDUSTRIAL WASTE

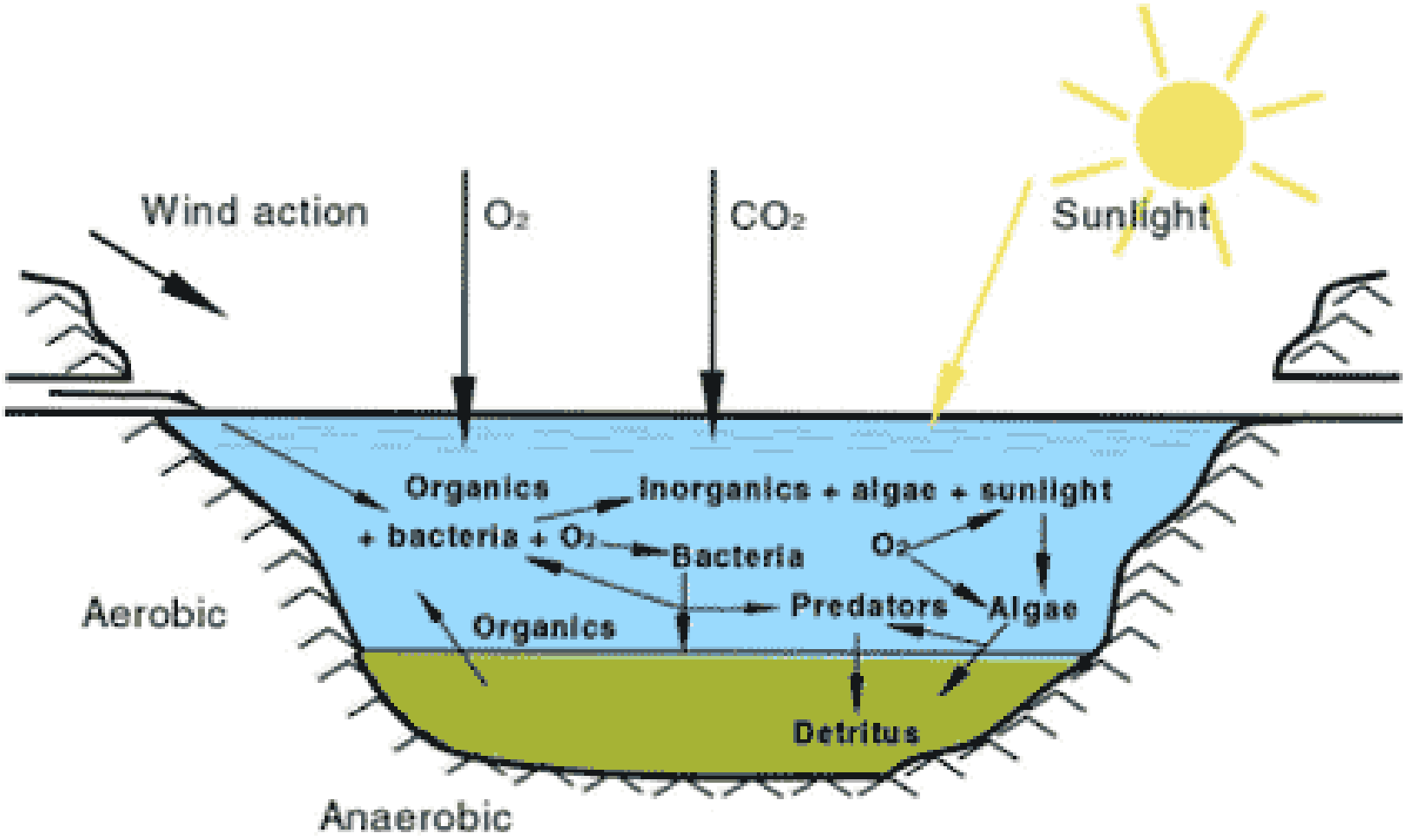
TYPES OF OXIDATION POND

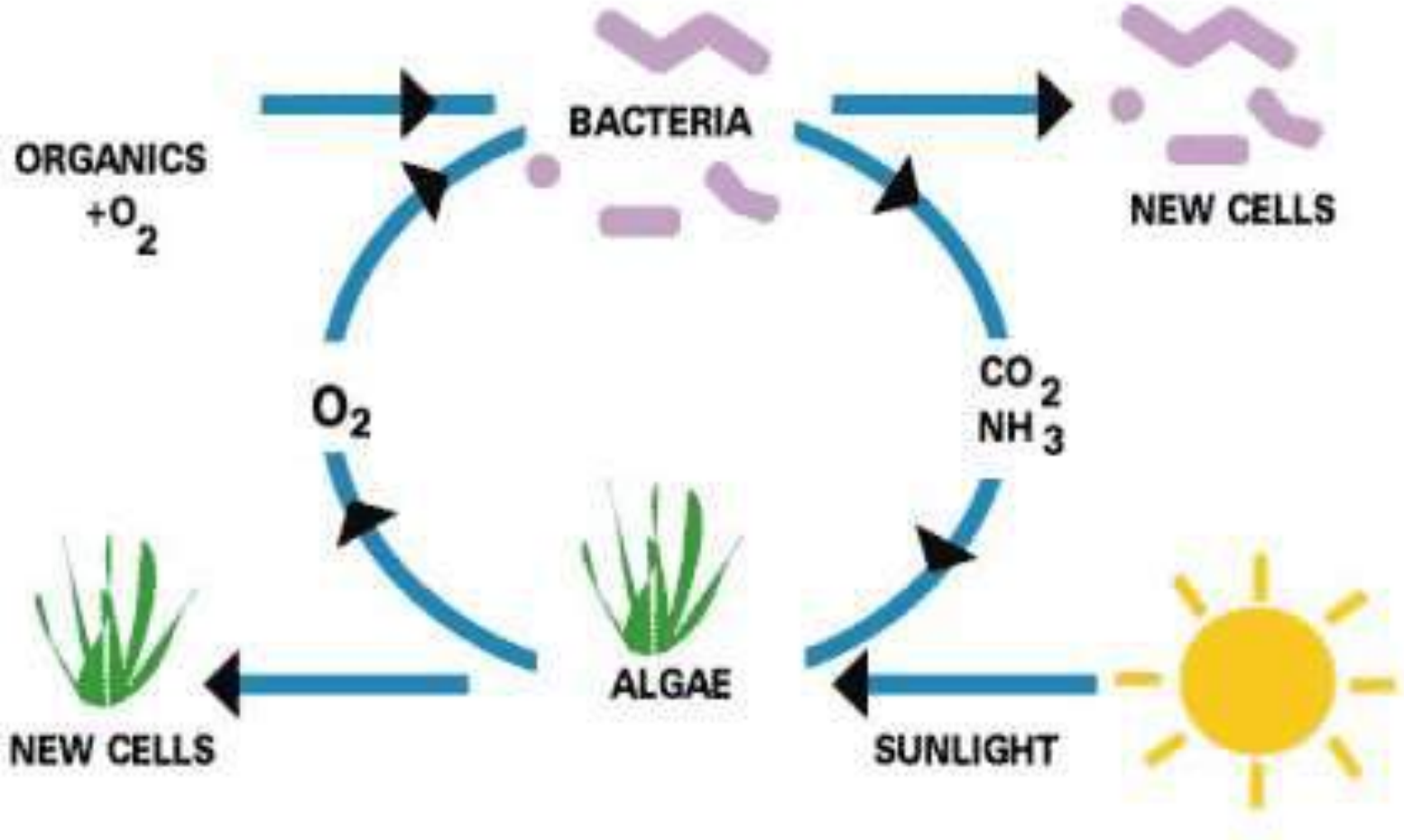
- AEROBIC PONDS
- ANAEROBIC PONDS
- FACULTATIVE PONDS
- MATURATION (TERTIARY) PONDS

APPLICATION OF PONDS

TYPE OF PONDS	APPLICATION
AEROBIC	TREATMENT OF SOLUBLE ORGANIC WASTE & EFFLUENTS FROM WASTE WATER TREATMENT PLANT
ANEROBIC	TREATMENT OF DOMESTIC AND INDUSTRIAL WASTE
FACULTATIVE	TREATMENT OF UNTREATED SCREENED WASTE WATER

AEROBIC & ANAEROBIC PONDS




ORGANICS
+O2
BACTERIA
NEW CELLS
O2
CO2
NH3
NEW CELLS
ALGAE
SUNLIGHT

AEROBIC PONDS

- THE AEROBIC POND IS SHALLOW IN WHICH LIGHT PENETRATES TO THE BOTTOM THERE BY MAINTAINING ACTIVE ALGAL PHOTOSYNTHESIS THROUGH OUT THE ENTIRE SYSTEM.

- VARIATION IN ‘DO’ AND ‘PH’ EFFECTS THE ENTIRE PROCESS IN SUCH PONDS.

ANAEROBIC PONDS

- THESE PONDS REQUIRES NO ‘DO’ FOR MICROBIAL ACTIVITY AS THE ORGANISMS USE O2 FROM COMPOUNDS SUCH AS NO3 , SO4 AS THEIR HYDROGEN ACCEPTORS AND GIVE END PRODUCT SUCH AS METHANE , CARBON DIOXIDE etc.

ANAEROBIC DECOMPOSITION

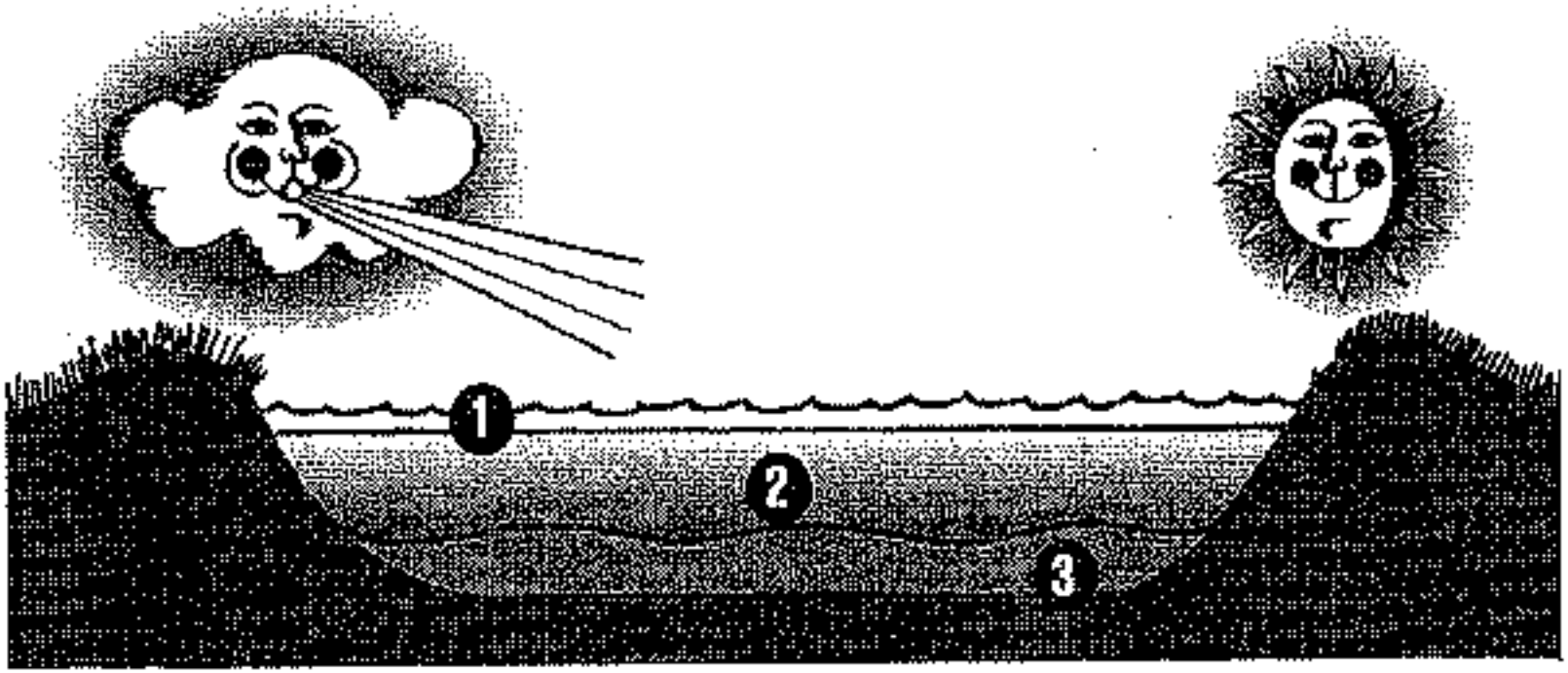
- IT TAKES PLACE IN TWO STEPS

1. DECOMPOSITION OF DISSOLVED ORGANIC WASTE BY ACID PRODUCING BACTERIA TO ORGANIC ACIDS
2. FURTHER DECOMPOSITION OF THESE ACIDS TO THE END PRODUCTS OF METHANE CARBON DIOXIDE AND WATER BY METHANE PRODUCING BACTERIA

FACULTATIVE PONDS

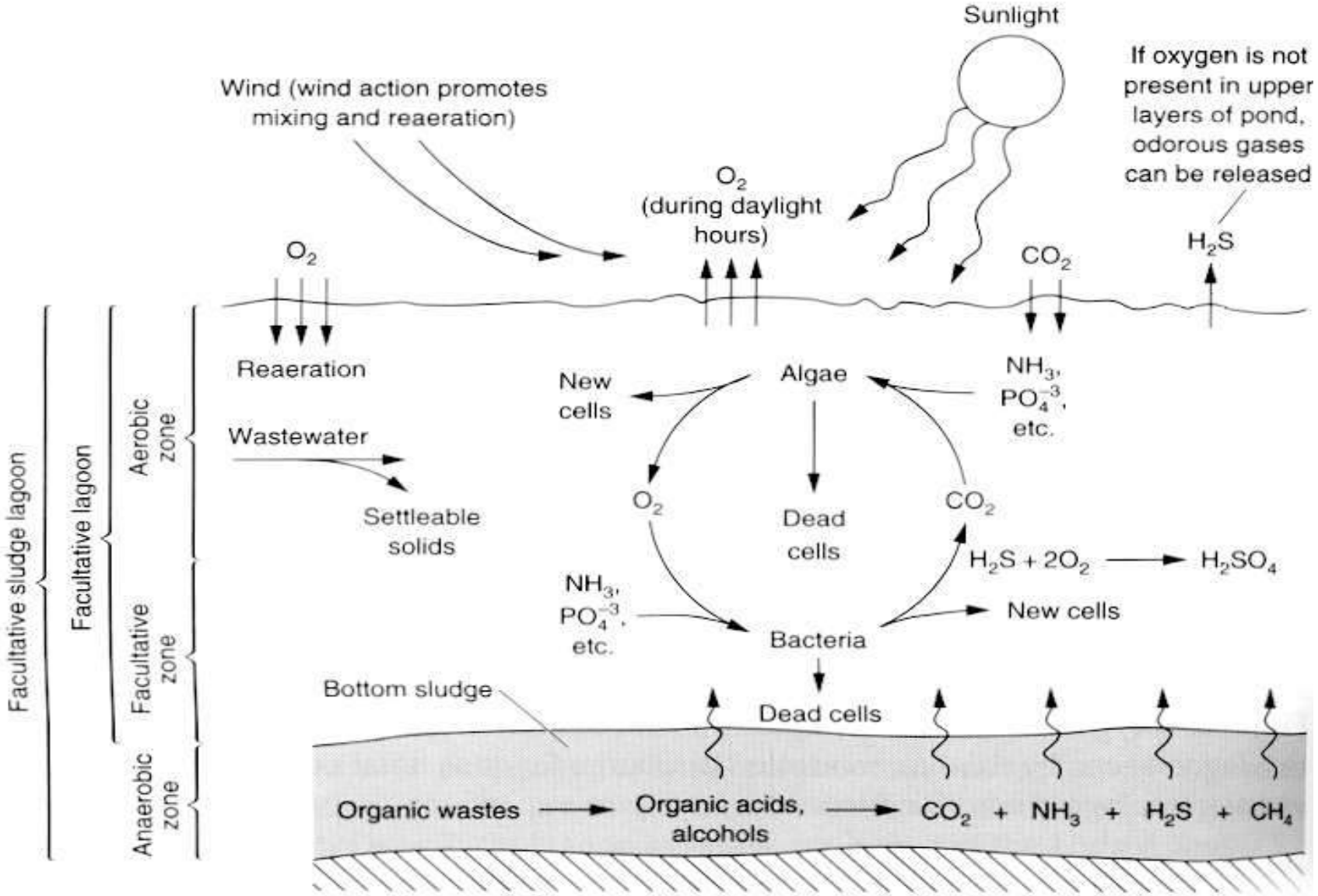
- THESE ARE NEITHER FULLY AEROBIC NOR FULLY ANAEROBIC. THEY ARE OFTEN ABOUT 1 TO 2 M IN DEPTH AND FAVOR ALGAL GROWTH ALONG WITH THE GROWTH OF AEROBIC, ANAEROBIC AND FACULTATIVE MICROORGANISMS. SUCH PONDS ARE PREDOMINANTLY AEROBIC DURING DAY LIGHT AS WELL AS FOR SOME HOURS OF THE NIGHT. IN THE FEW REMAINING HOURS THE POND BOTTOM MAY TURN ANAEROBIC

LAYERS OF FACULTATIVE PONDS



The top layer (1) in a facultative lagoon is called the aerobic zone, the second layer (2) is called the facultative zone, and the third layer (3) is the anaerobic zone.

INTERACTION



ZONES OF FACULTATIVE POND

1. AEROBIC ZONE
2. ANAEROBIC ZONE
3. FACULTATIVE ZONE

THE DECOMPOSITION OF INCOMING ORGANIC WASTE AND PRODUCTS OF ANAEROBIC DECOMPOSITION IS DONE BY FACULTATIVE BACTERIA.

MATURATION PONDS

- THESE ARE SIMILAR TO AEOBIC PONDS BUT ARE VERY LIGHTLY LOADED WITH ORGANIC WASTES.
- GENERALLY USED FOR UPGRADING EFFLUENTS FROM CONVENTIONAL SECONDARY TREATMENT PROCESSES.
- THE MAIN OBJECTIVE OF MATURATION PONDS IS TO REMOVE PATHOGENIC MICRORGANISMS PRESENT IN THE WASTEWATER, WHICH OCCUR MAINLY DUE TO SUNLIGHT IN THE WATER COLUMN.

PROS AND CONS OF USING STABILIZATION PONDS

PROS

- Simplicity to built, operate and maintain.
- Low operational cost.
- Good quality on effluent

CONS

- Need large areas.
- Limited and dependent on weather.
- Quality of effluent varies.

What is Wastewater?

- Wastewater is a term that is used to describe waste material that includes industrial liquid waste and sewage waste that is collected in towns and urban areas and treated at urban wastewater treatment plants.

Wastewater treatment

- A process to convert wastewater - which is water no longer needed or suitable for its most recent use - into an effluent that can be either returned to the water cycle with minimal environmental issues or reused.

Wastewater Contaminants

- Suspended solids
- Biodegradable organics (e.g., BOD)
- Pathogenic bacteria
- Nutrients (N & P)

Where does wastewater come from?

- Residences

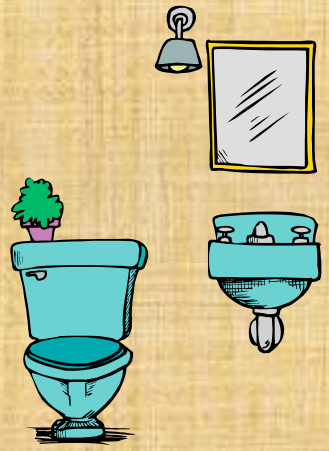
— human and animal excreta and waters used for washing, bathing, and cooking.

- Commercial institution
- Dairy and industrial establishment

— slaughterhouse waste, dairy waste, tannery wastewater, etc.

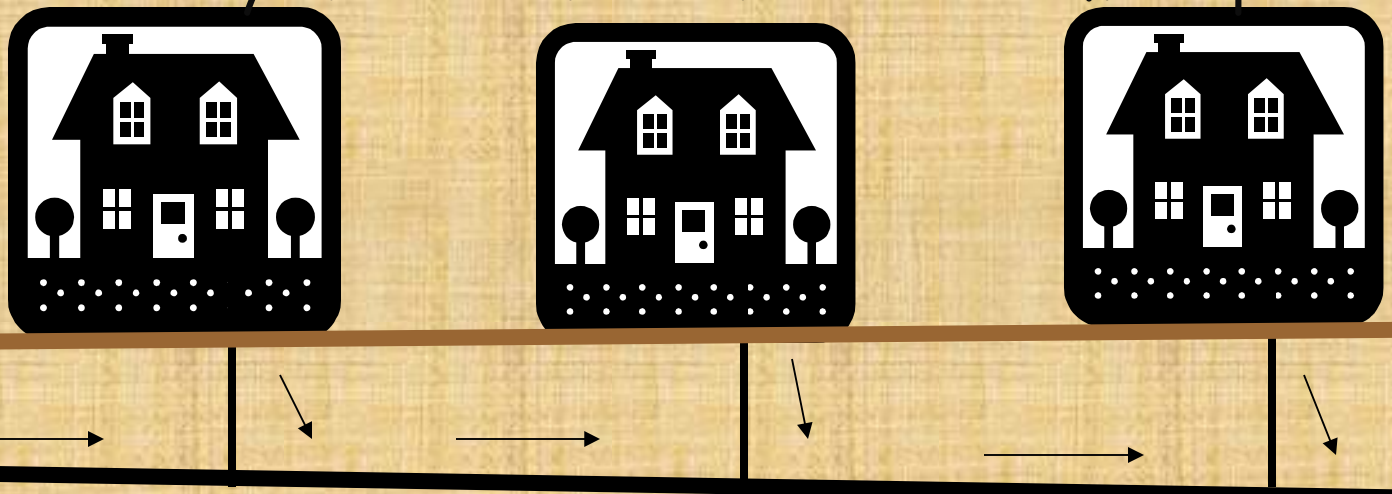
Where does it all go!

Where does the water from the washer go?



When you flush the toilet where does the contents go?

By gravity flow, the waste is on its way to your local wastewater treatment plant!




Auto exhaust
Motror oil
Lubricants
Gasoline
Tire wear
Leaves
Grass clippings
Pesticides, Pet wastes
Paint
Fertilizer
Lead
Phosphorus, nitrogen
Bacteria, BOD
Toxic materials
Phosphorus, nitrogen, bacteria, BOD
Lead, cadmium, zinc, hydrocarbons
Sediments, BOD
Zinc, copper, chromium
BOD, bacteria
Eroded soil
Metal corrosion
Street litter
To nearby surface water

Why treat wastewater?

- Causes a demand for dissolved oxygen (lower DO levels of streams)
- Adds nutrients (nitrate and phosphate) to cause excessive growth
- Increases suspended solids or sediments in streams (turbidity increase)

Objectives of WWT

- Reduce organic content i.e., BOD
- Removal/reduction of nutrients i.e., N,P
- Removal/inactivation of pathogenic microbes

Levels of Treatment

Primary

- removal by physical separation of grit and large objects (material to landfill for disposal)
- Sedimentation and screening of large debris

Secondary

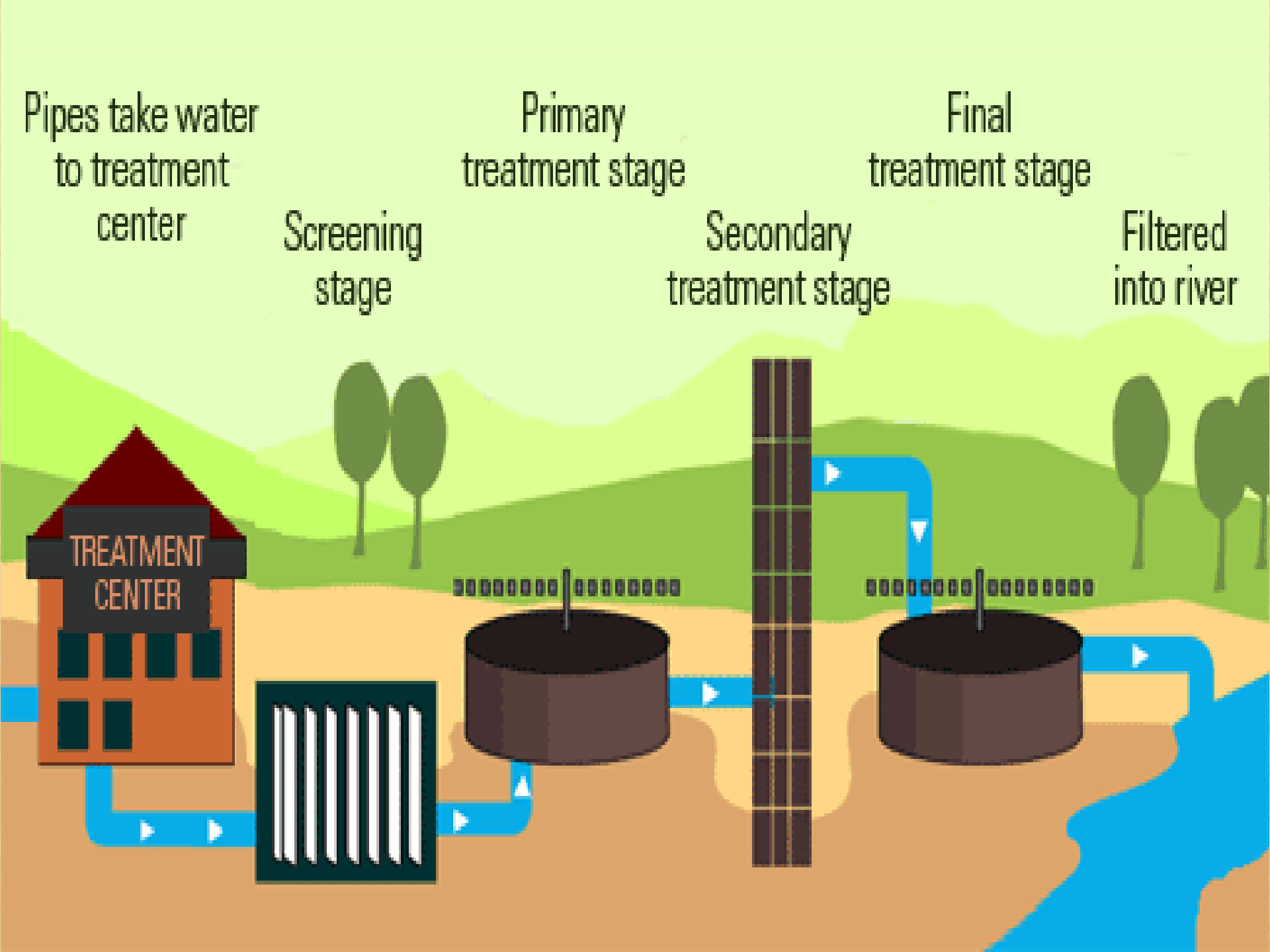
- Biological and chemical treatment
- aerobic microbiological process (sludge)

Mostly dead microbes

$$\text{organic matter} + O_2 \rightarrow CO_2 + NH_3 + H_2O$$

$$NH_3 \rightarrow NO_3^-$$

aquatic nutrient


Pipes take water to treatment center
Screening stage
Primary treatment stage
Secondary treatment stage
Final treatment stage
Filtered into river
TREATMENT CENTER

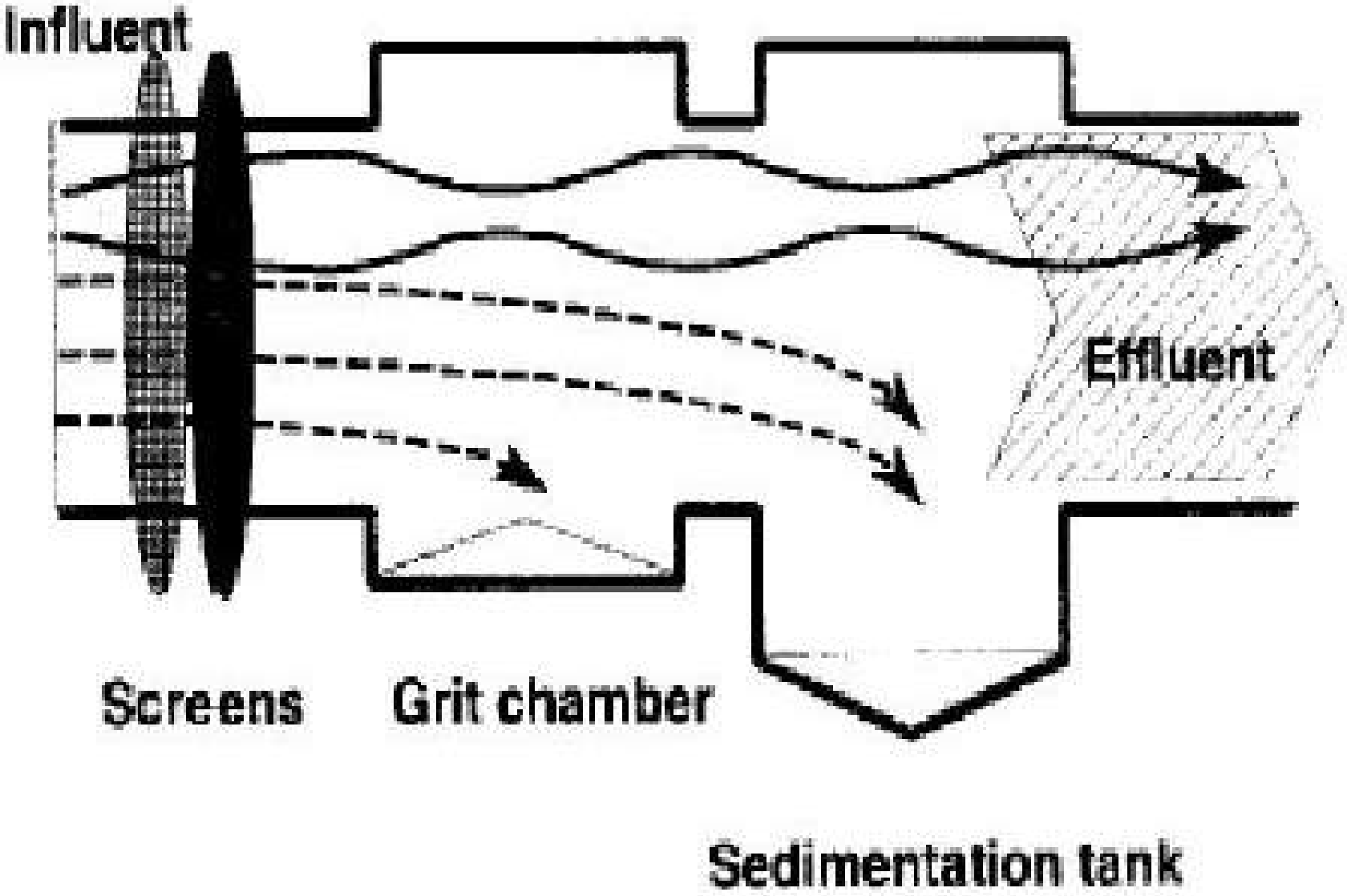
Treatment stages - Primary treatment

- typical materials that are removed during primary treatment include
  - fats, oils, and greases
  - sand, gravels and rocks
  - larger settle-able solids including human waste, and
  - floating materials

Methods used in primary treatment

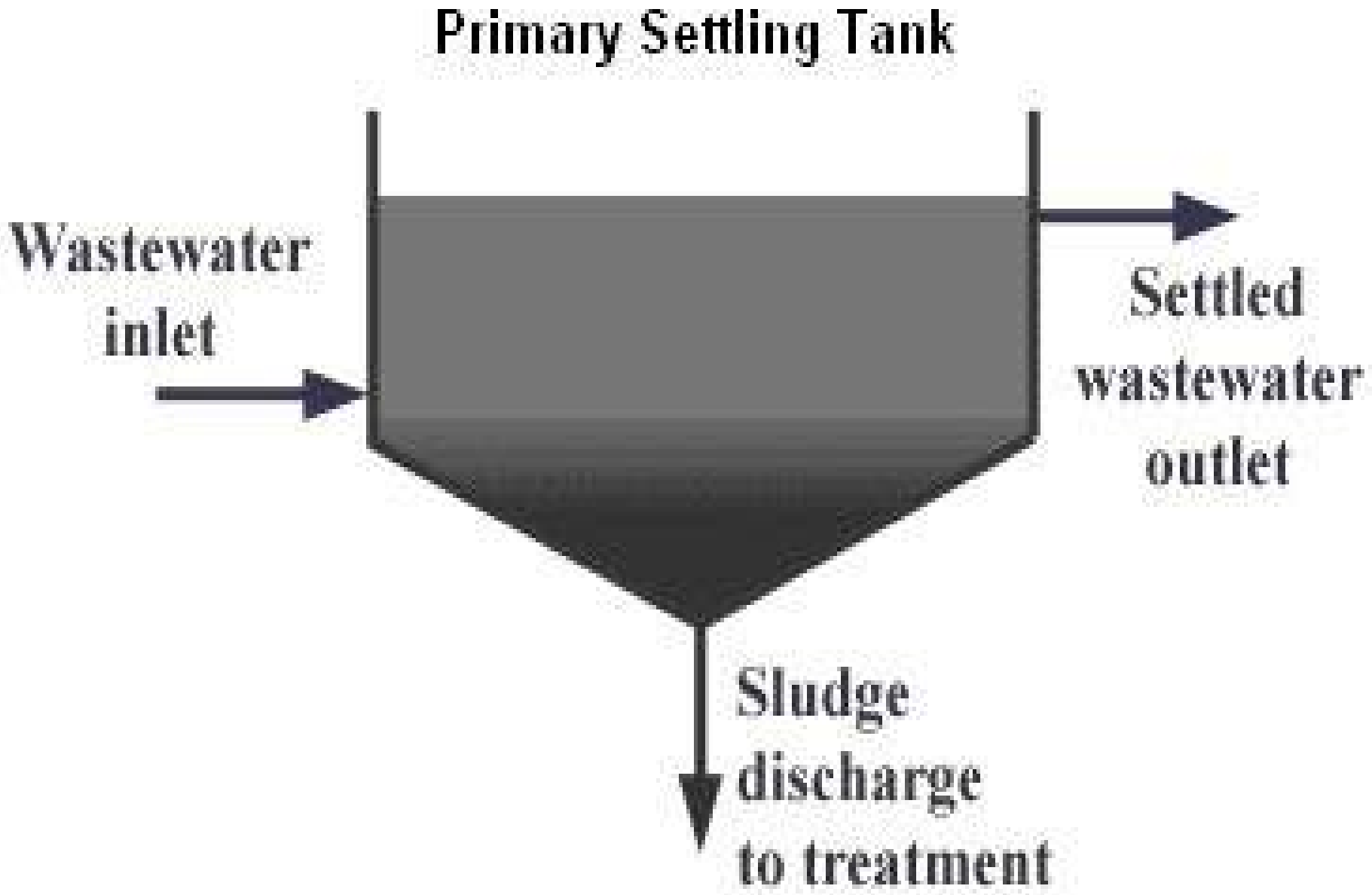
- Bar screens
- Grinding
- Grit Chamber
- Sedimentation Tank- primary Settling tank
- Chlorination of effluent

PRIMARY TREATMENT



Sedimentation Tank- primary Settling tank

- Remove grease, oil
- Fecal solid settle, floating material rise to the surface
- Produce a homologous liquid for later biological treatment
- Fecal sludge are pumped to sludge treatment plant


Primary Settling Tank
Wastewater inlet
Settled wastewater outlet
Sludge discharge to treatment

Secondary treatment

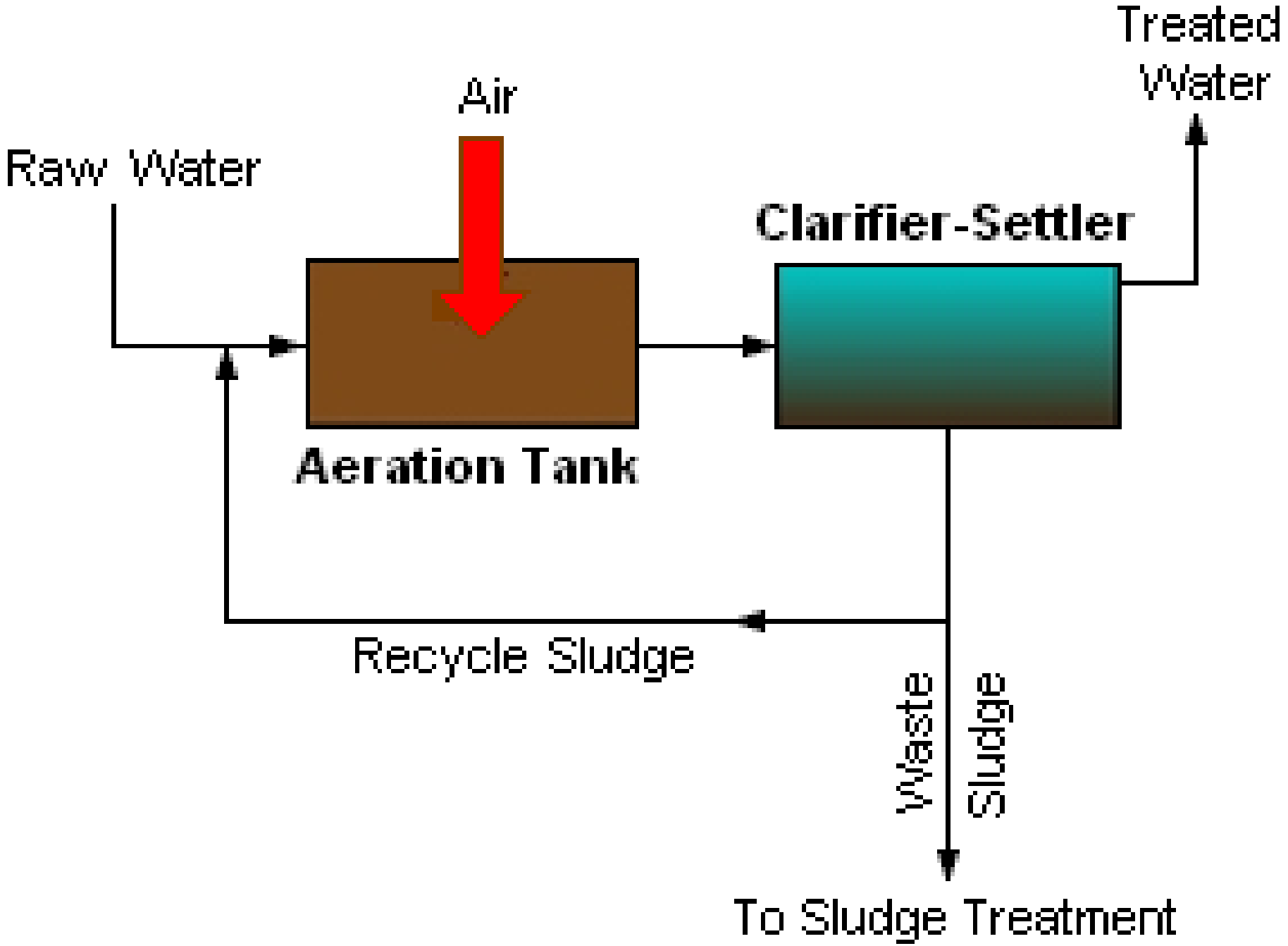
- Biological treatment
  - activated sludge
  - trickling filter
  - oxidation ponds

Activated sludge process

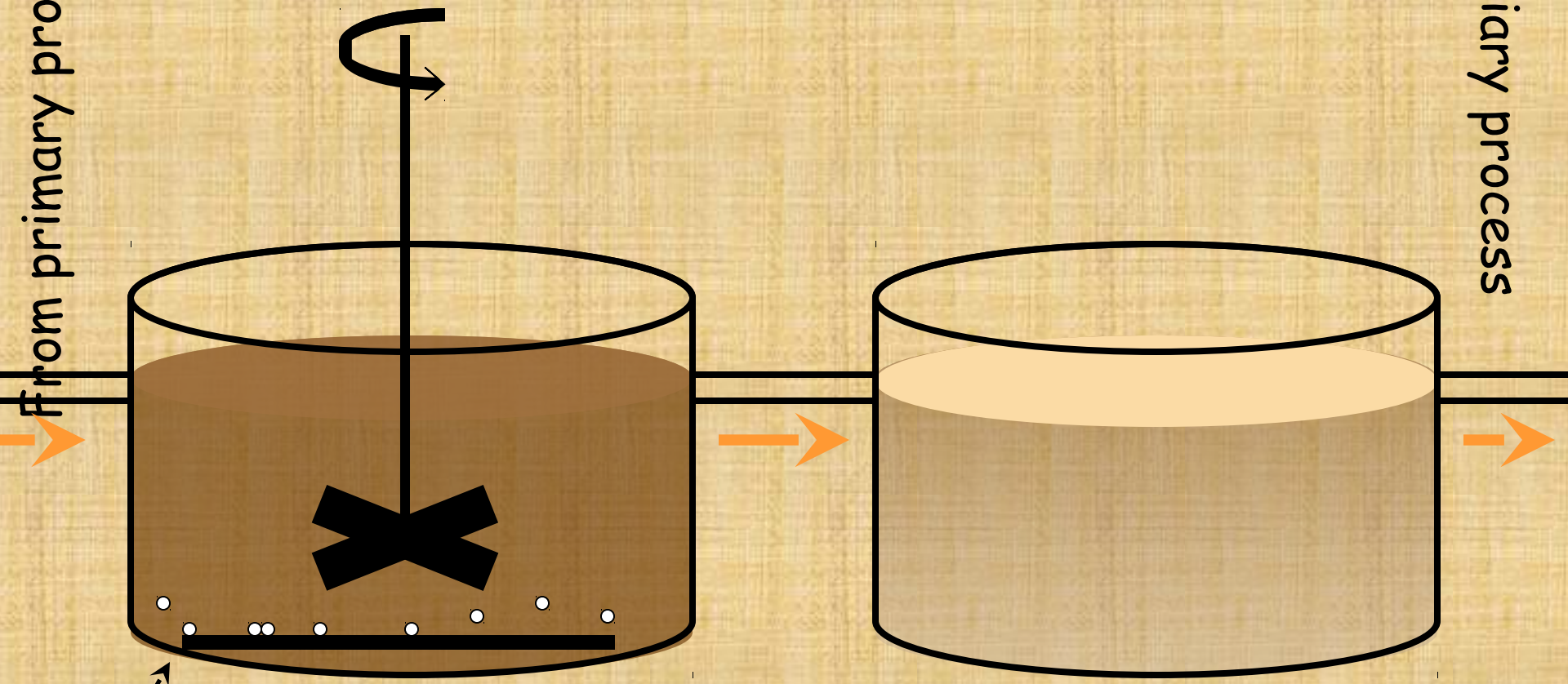
- Primary wastewater mixed with bacteria-rich (activated) sludge and air or oxygen is pumped into the mixture
- Both aerobic and anaerobic bacteria may exist
- Promotes bacterial growth and decomposition of organic matter
- BOD removal is approximately 85%
- Microbial removal by activated sludge
  - 80-99% removal of bacteria
  - 90-99% removal of viruses

5 physical components

- Aeration tank
  - oxygen is introduced into the system
- Aeration source
  - ensure that adequate oxygen is fed into the tank
  - provided pure oxygen or compressed air
- Secondary clarifiers
  - activated-sludge solids separate from the surrounding wastewater
- Activated sludge outflow line
  - Pump activated sludge back to the aeration tank
- Effluent outflow line
  - discharged effluent into bay or tertiary treatment plant


Treated
Water
Air
Raw Water
Clarifier-Settler
Aeration Tank
Recycle Sludge
Waste
Sludge
To Sludge Treatment

Secondary process



Trickling filters

- Trickling filters are beds made of coke (carbonized coal), limestone chips or specially fabricated plastic media
- Optimize their thickness by insect or worm grazing
- The primary wastewater is sprayed over the filter and microbes decompose organic material aerobically.
- Low pathogen removal
  - Bacteria, 20-90%
  - Viruses, 50-90%
  - Giardia cysts, 70-90%

Tricking filters

Stabilization or oxidation ponds

- Oxidation ponds are a few meters deep, and up to a hectare in size.
- They are low cost with retention times of 1 to 4 weeks.
- Odor and mosquitoes can be a problem
- Pathogen removal:
  - Bacteria, 90-99%
  - Virus, 90-99%
  - Protozoa, 67-99%
- Mechanisms include the long detention time, high pH (10-10.5) generated by photosynthesis, predation, sunlight, temperature

Continued…

Stabilization ponds are the preferred wastewater treatment process in developing countries due to low cost, low maintenance. This is balanced by larger land requirement.

When the treatment is done…

- Effluent back to stream after
  - a final carbon filtration and
  - chlorination/de-chlorination
- Sludge – very nutrient rich
  - applied directly to land as fertilizer
  - incinerated (good fuel after drying)
  - composted

Sludge Treatment Processes

Thickening (water removal)

↓

Digestion (pathogen inactivation and odor control)

↓

Conditioning (improved dewatering with alum and high temp, 175-230^{o} C)

↓

Dewatering (pathogen inactivation and odor control)

↓

Incineration (volume and weight reduction)

↓

Final disposal

Wastewater Treatment Alternatives

- Septic Tanks
- Constructed Wetlands
- Composting

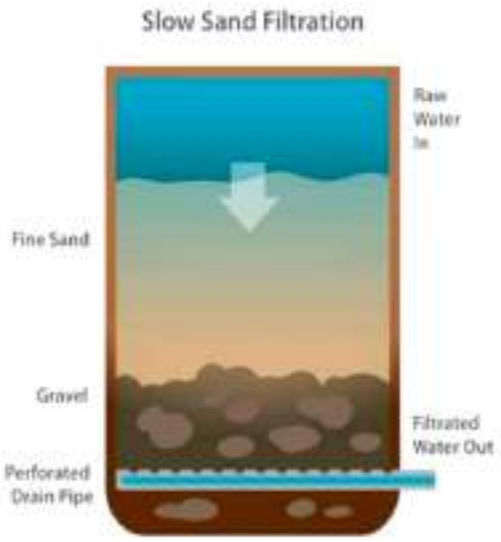
ADVANCED WASTEWATER TREATMENT

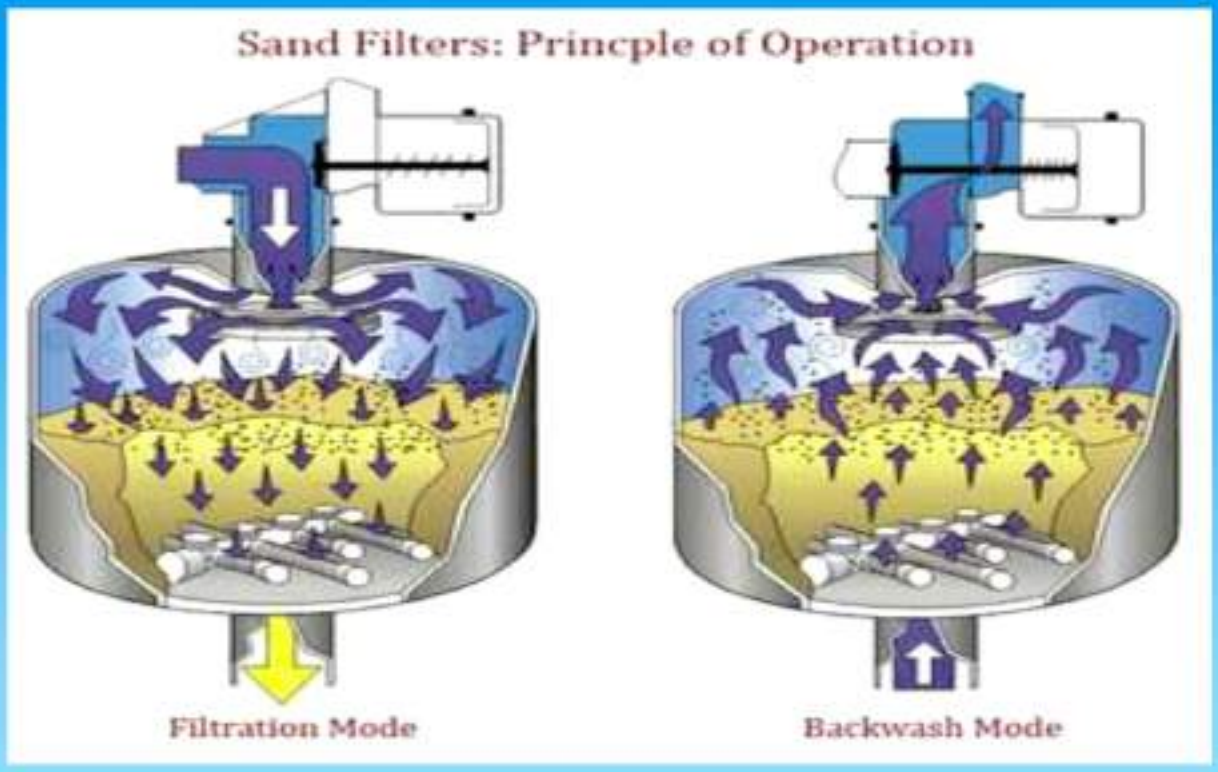
* To remove residual nutrients
* To remove pathogens
* To reduce total dissolved solids

* Filtration
* Carbon Adsorption
* Phosphorus Removal
* Nitrogen Control

Filtration

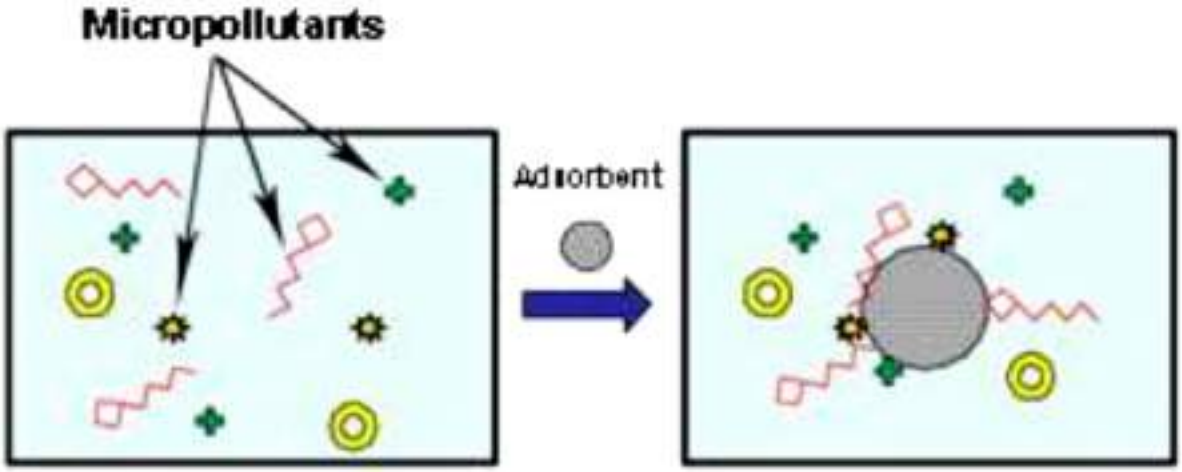
* To remove residual suspended solids including unsettles microorganisms





Carbon adsorption

* To remove refractory organic compounds



Nitrogen Removal

The most common for the removal of ammonia from wastewater are:

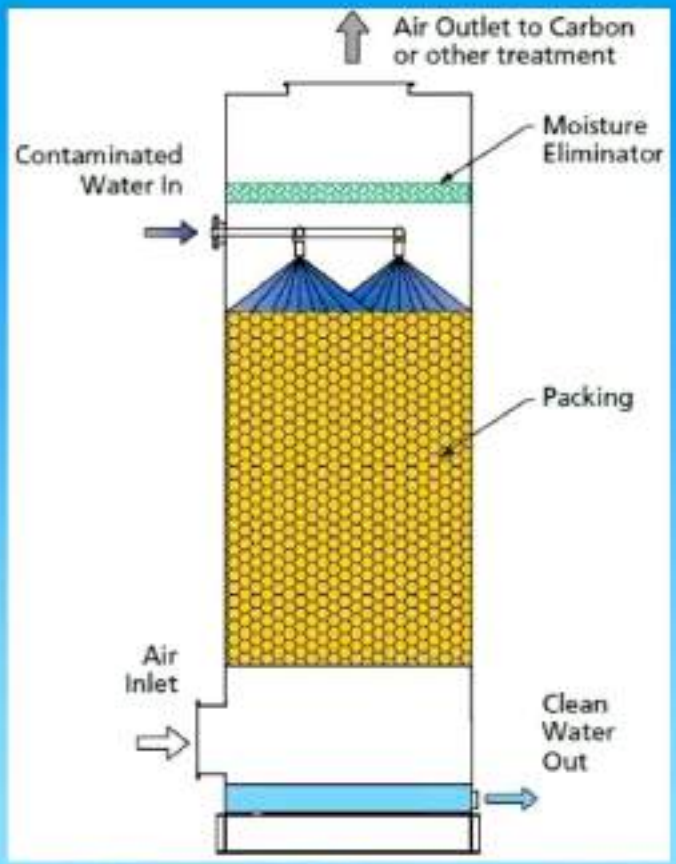
* Air Stripping
* Biological Nitrification and Denitrification

Air Stripping

* The conversion ammonium to gaseous phase and then dispersing the liquid in air, thus allowing transfer of the ammonia from wastewater to the air

$$NH_4^+ + OH^- \leftrightarrows H_2O + NH_3\uparrow$$

* Addition of lime
* The pH must be greater than 11 for complete conversion



Air stripping column shown is used to remove ammonia from water and waste water feedstreams.

Packed Tower Air Stripper

ION EXCHANGE

Global NEST

USE OF ION EXCHANGE FOR REMOVAL OF AMMONIUM: A BIOLOGICAL REGENERATION OF ZEOLITE

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ABSTRACT

Nitrogen in the Ammonia form can have deleterious effects in water resources. Ion Exchange by zeolite and biological Nitrification processes are two proposed methods for removing Nitrogen compounds from wastewater and effluents. The main objective of this research was to investigate the efficiency of Nitrifying bacteria for regenerating Clinoptilolite zeolite. In this research, the Semnan Clinoptilolite zeolite was supplied in mesh 30. Then the capacity of zeolite in ammonium removal was determined in column system.

To cultivate of nitrifying bacteria a sludge sample was taken from a domestic wastewater treatment plant and added to a 10 l aeration tank. Ammonium and other nutrients were added in the reactor daily over a month period and the effect of nitrate, anion and MLVSS on nitrification process have been determined. After saturation of zeolite with ammonium, biological regeneration was done by contact of zeolite and nitrifying bacteria in column system. In this stage slurry of nitrifying bacteria is pumped up flow through the zeolite column and recycled to the aeration tank. The effluent containing the displaced ammonium is oxidized to nitrate by the nitrifying bacteria. Then the nitrified brine is clarified in a sedimentation tank and stored for reuses.

The results showed that the cation exchange capacity was 10.36 (in breakthrough point) and 19.36 mg NH_4^+ g^{-1} zeolite as total capacity. The results indicated that nitrification accelerated by increasing in MLVSS concentration and concentration of nitrate remains in solution. The results obtained from bioregeneration tests of zeolite showed that the efficiency was 97.7 to 98.8% in period of 3.5 to 5.5 hours.

Based on the results, since regeneration is achieved in high concentration of nitrate, the use of nitrifying sludge in several cycles is possible and the use of system can be appreciated to an alternative or complement method for removing NH_4^+ from effluent.

* A filtered waste water can be passed through a bed of zeolite to effect a 90-97% ammonium removal.

BREAKPOINT CHLORINATION

$$NH_4 + HOCl \rightarrow NH_2Cl \text{ (monochloramine)} + H_2O + H^+$$

$$2NH_2Cl + HOCl \rightarrow N_2\uparrow + 3HCl + H_2O$$

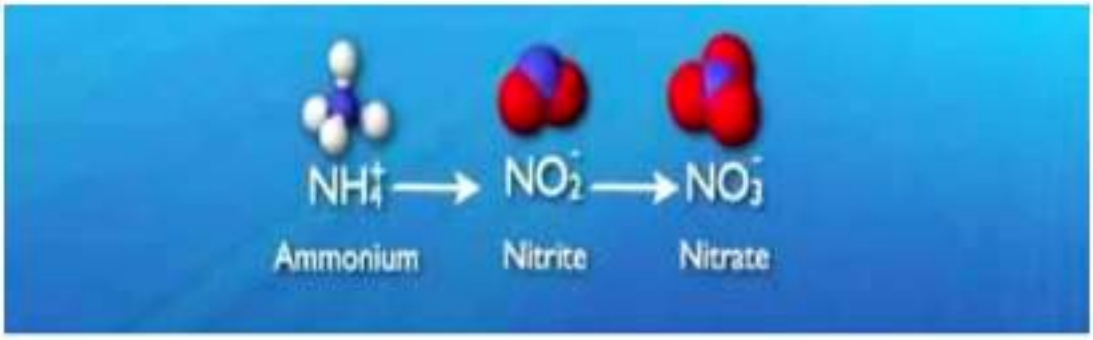
Breakpoint chlorination is a widely used process that oxidizes ammonia to nitrogen gas

Biological Nitrification and Denitrification

Nitrification followed by Denitrification to covert nitrogen ammonia finally to gaseous nitrogen

Nitrification

* The biological conversion of ammonium to nitrate nitrogen



Nitrosomonas

First step: $NH_4^+ + 3/2\ O_2 \longrightarrow NO_2^- + 2H^+ + H_2O$
(Nitrite)

Nitrobacter

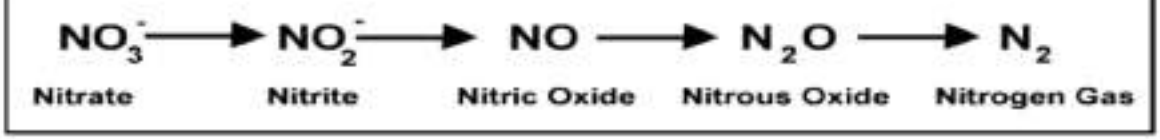
Second step: $NO_2^- + 1/2\ O_2 \longrightarrow NO_3^-$
(Nitrate)

Overall reaction: $NH_4^+ + 2\ O_2 \longrightarrow NO_3^- + 2H^+ + H_2O$

Denitrification

* Denitrification occurs when oxygen levels are depleted and nitrate becomes the primary electron acceptor source for microorganisms.

Denitrification Reaction Sequence



Denitrification process requires the following:

* Denitrifying bacteria
* Carbon source
* Oxygen source

$$N0_3^- + 5/6\ CH_3OH \longrightarrow \tfrac{1}{2}\ N_2 + 5/6\ CO_2 + 7/6\ H_20 + OH^-$$

$$NH_4^+ + \left(\frac{3}{2}\right)O_2 \rightarrow NO_2^- + 2H^+ + H_2O$$

$$NO_2^- + \left(\frac{1}{2}\right)O_2 \rightarrow NO_3^-$$

Nitrification

$$NO_3^- + \left(\frac{1}{3}\right)CH_3OH \rightarrow NO_2^- + \left(\frac{1}{3}\right)CO_2 + \left(\frac{2}{3}\right)H_2O$$

$$NO_2^- + \left(\frac{1}{2}\right)CH_3OH \rightarrow \left(\frac{1}{2}\right)N_2\,(gas) + \left(\frac{1}{2}\right)CO_2 + \left(\frac{1}{2}\right)H_2O + OH^-$$

Denitrification

Phosphorus Removal

Phosphorus in waste exists in three forms :

* ortho-phosphate (H_3PO_4)
* polyphosphate and ($H_4P_2O_7$)
* organic phosphate (ATP, ADP)

Could be done thru:

* Chemical Precipitation
* Biological Phosphorus Removal

Chemical precipitation is used to remove the inorganic forms of phosphate by the addition of a coagulant to wastewater .The multivalent metal ions most commonly used are:

* calcium
* aluminum and
* iron

Precipitation by Calcium

Calcium is added as a lime ($Ca(OH)_2$):

$$10Ca^{2+} + 6PO_4^{3-} + 2OH^- \rightleftarrows Ca_{10}(PO_4)_6(OH)_2(s)$$

Precipitation by Aluminum

Alum or hydrated aluminium sulphate is widely used precipitating phosphates and aluminium phosphates ($AlPO_4$). The basic reaction is:

$$Al^{3+} + H_nPO_4^{(3-n)-} \rightarrow AlPO_4(s) + nH^+$$

Precipitation by Iron

Ferric chloride or sulphate and ferrous sulphate also know as copperas, are all widely used for phosphorous removal. The basic reaction is:

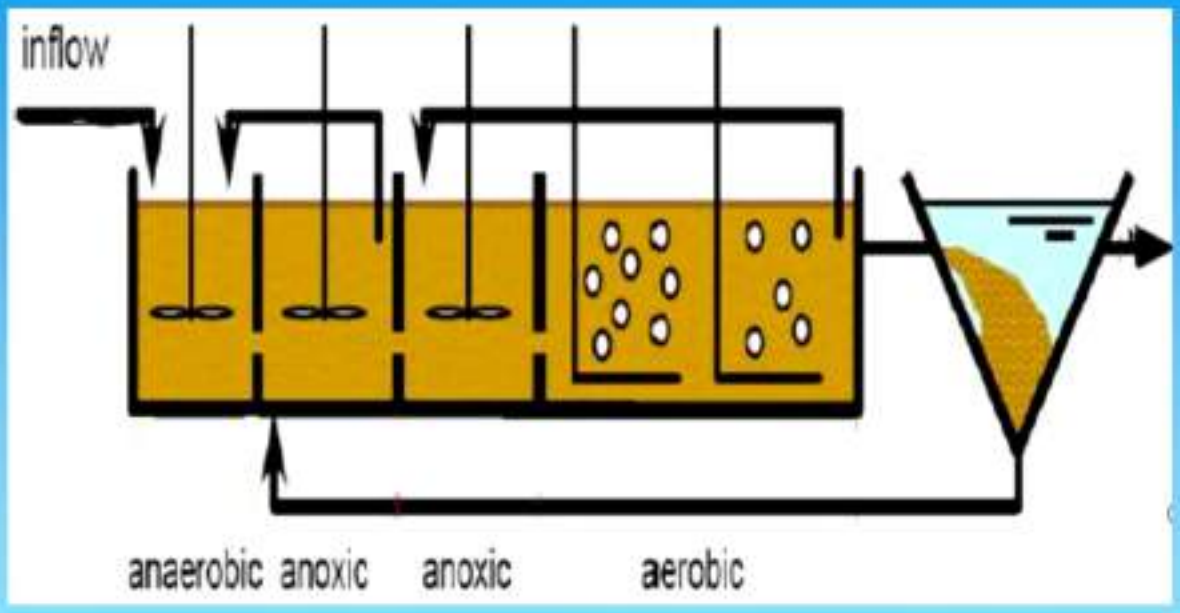
$$Fe^{3+} + H_nPO_4^{(3-n)-} \rightarrow FePO_4(s) + nH^+$$

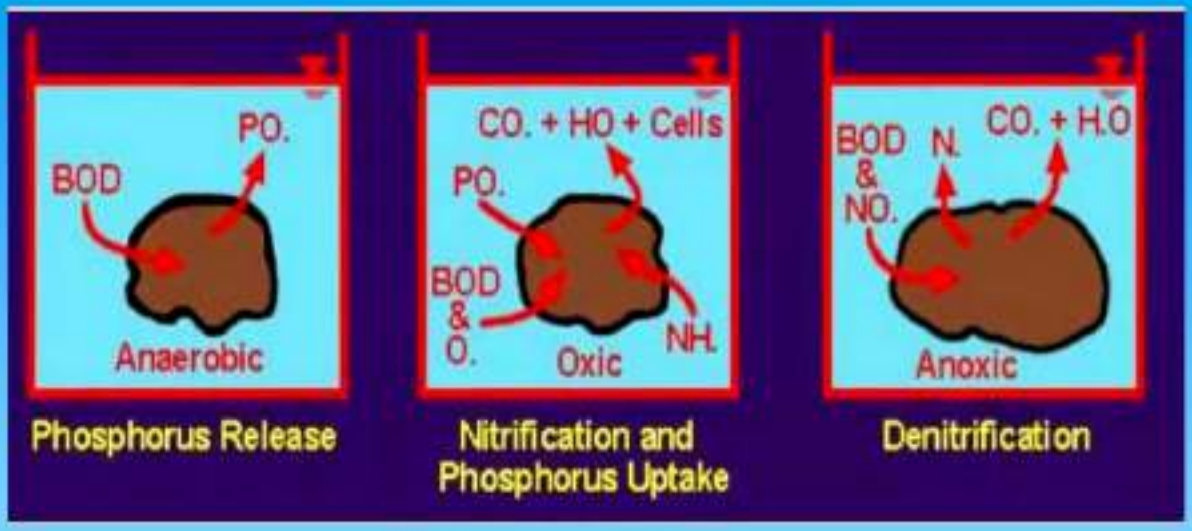
Enhanced biological phosphorus removal (EBPR)

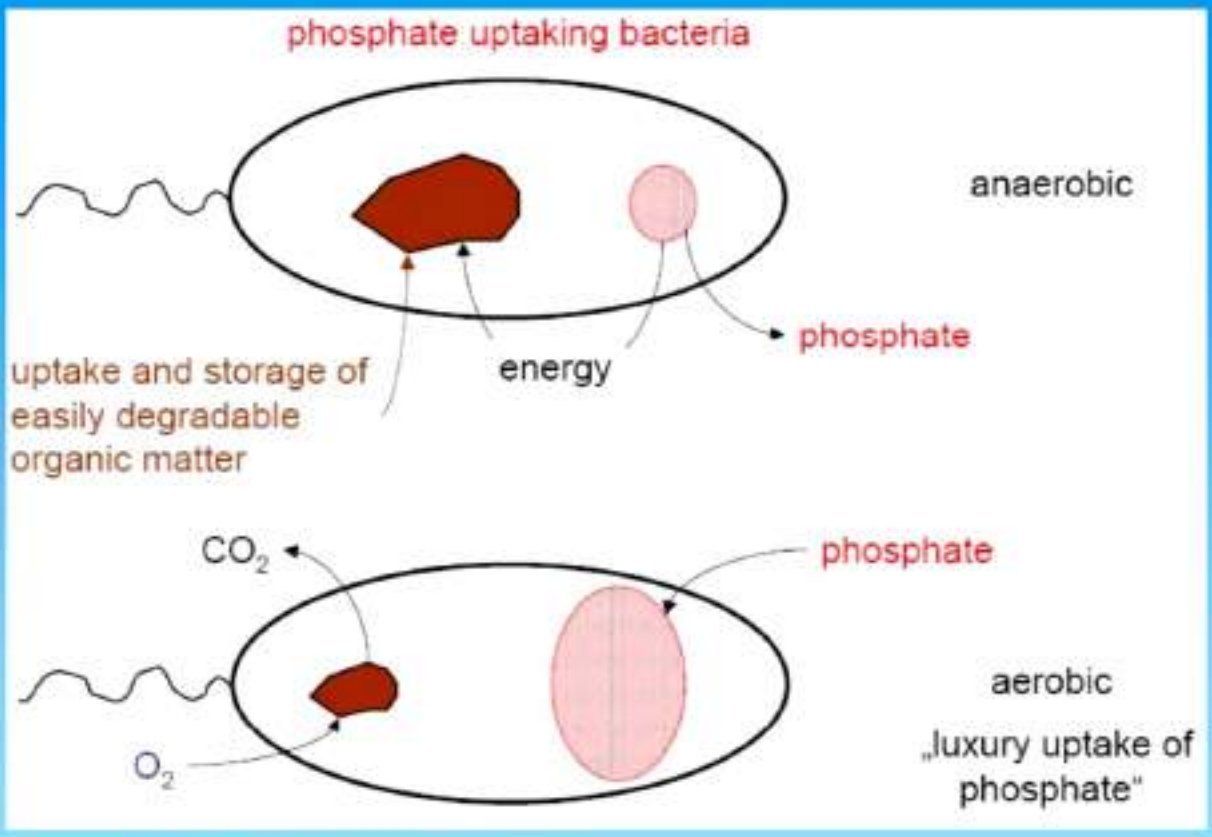
A sewage treatment configuration applied to activated sludge systems for the removal of phosphate.

BPR is achieved by :

* Growing phosphorus-accumulating organisms (PAOs)
* In anaerobic to aerobic conditions







Disinfection

* Chlorination
* Ozonation
* Ultraviolet radiation

Chlorination

* Chlorine may be applied in a number of forms such as chlorine gas, sodium hypochlorite or chlorine dioxide

$$Cl_2 + H_2O \rightarrow HOCl + H + Cl$$

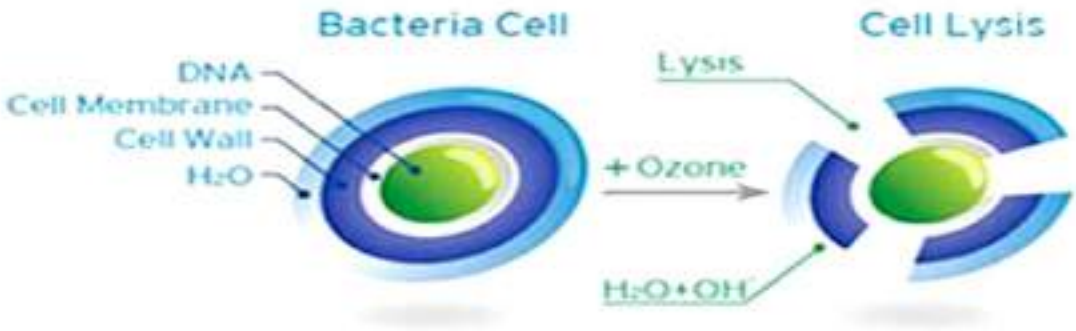
Chlorine Gas — Hypochlorous Acid } Strong oxidizing agent

* Chlorine disinfection works through oxidation of cell walls leading to cell lysis (bacterial) or inactivation of functional sites on the cell surface

- Disadvantages:
  - Free and combined chlorine residues are toxic to aquatic organisms.
  - The potential formation of organo-chlorinated derivatives
- Advantage:
  - low cost & effective

Ozonation

* Ozone gas (03) can be used as a disinfectant even though it does not leave a residual in the water being treated.



* Advantages:
  * safer than chlorination
  * fewer disinfection by-product
  * the elimination of odors
* Disadvantages:
  * high cost

UV Radiation

Involves passing a film of wastewater within close proximity of a UV source (lamp)

* Damage the genetic structure of bacteria, viruses and other pathogens.
* Advantages: no chemicals are used, high efficiency against a wide range of microorganisms
* Disadvantages: high maintenance of the UV-lamp