



BUILDING SERVICES

Lectures Notes

Government Polytechnic, Bhubaneswar

Diploma in Architecture Assistantship | IV Semester

Phula Dei
Lect. in AA

Probable 2 marks Questions —

- ① Define Per Capita Demand.
- ② Define Trap.
- ③ Define Water Seal.
- ④ What do you mean by "Water Supply"?
- ⑤ What is Water Carriage System?
- ⑥ Mention the types of Water Carriage System.
- ⑦ Define Intermittent Supply System.
- ⑧ Which gas is produced in Sludge digestion Tank?
- ⑨ Define Combined Sewage.
- ⑩ What is Sullage?
- ⑪ Write any two requirements of Water Supply System.
- ⑫ Mention any two advantages of Pumping System.
- ⑬ Define Manhole.
- ⑭ What is Gully Trap?
- ⑮ Define Ventilation Pipe.
- ⑯ Systems of water supply.
- ⑰ Per capita domestic demand in India (CPWD)
- ⑱ Disinfection.
- ⑲ Distribution reservoir.

Probable 6 marks Questions —

- ① Short notes —
 - a) Urinals
 - b) Gully Traps

- (c) Intercepting Traps
- (d) Water closet
- (e) Dead End System
- (f) Dual System
- (g) Imhoff Tank
- (h) Soak Pit

Distinguish between the following :- 16

- (a) Sewage and Sullage
- (b) Conservancy System & Water Carriage System
- (c) Separate System and Combined System of Sewerage
- (d) Gully Trap & Floor Trap
- (e) P-Trap & Q-Trap
- (f) Continuous System & Intermittent Supply System

Sketches —

- (a) Plan & Section of Soak Pit
- (b) Plan & Section of Inspection Chamber
- (c) Plan & Section of Manhole
- (d) Sketch of Washbasin
- (e) Sketch of Bidets
- (f) Sketch of Septic Tank
- (g) Sketch of Gully Trap

- ② Distinguish between the following :- 16
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- ③ Sketches —

- Plan & Section of Soak Pit
- Plan & Section of Inspection Chamber
- Plan & Section of Manhole
- Sketch of Washbasin
- Sketch of Bidets
- Sketch of Septic Tank
- Sketch of Gully Trap

- Sketch of Floor Trap
- Sketch of Q-Trap
- Sketch of Valves

With the help of neat sketches, write short notes on the following. 16

- Sluice valve (gate valves)
- Check-valve (Reflux)
- Drain valve (scour valves)
- Air valves
- Relief valves
- Stop cocks
- Bib cocks
- Fire hydrants
- Ferrule
- Water meter

- 1) Describe, with sketches, the methods of water distribution system.
- 2) Describe the with sketches, the layout of water distribution system.
- 3) Write the basic idea of water treatment processes.
- 4) What are the requirements of a good distribution system? Describe in brief various types of distribution systems.
- 5) What do you understand by continuous and intermittent supply system of water? Compare both in respect to their merits and demerits.
- 6) Describe importance of Sanitation to public health.
- 7) Describe refuse types, collection and disposal.
- 8) Discuss with layout of a simple house drainage system of a residential house.
- 9) Describe with neat sketch the construction, function and use of Septic Tank.
- 10) What are the various systems of Sewerage? Describe the merits & demerits of each.
- 11) Design a septic tank for a hostel 300 boarders assuming reasonable data.

- 12) Describe the Conservancy system and water carriage system and state the merits and demerits of these systems.

ELEMENTS OF DOMESTIC SANITATION

The elements of domestic sanitation are:-

- (i) Septic tank
- (ii) Soak pit
- (iii) Manhole
- (iv) Inspection chamber.
- (v) Sanitary connections and fittings.
- (vi) Traps
- (vii) Anti Siphon and ventilation pipes
- (viii) Soil pipe and waste pipe.

SEPTIC TANK

Theory:-

- * The theory of septic tank is based on the principle of sedimentation of sewage and digestion of sludge.
- * In this tank, the sewage is detained for some period. During this detention period, the sewage is decomposed by anaerobic bacteria and the sludge is deposited at the bottom (as sedimentation tank).
- * The digestion of sludge is carried out by the anaerobic bacteria (as digestion tank).
- * The effluent is clear and it is discharged into the soak pit constructed at a suitable place.

Use:-

- * The septic tank is suitable for the towns where it is not possible to establish the water carriage system.
- * It is provided in residential buildings, hotels, hostels, hospitals, colleges, schools, etc.

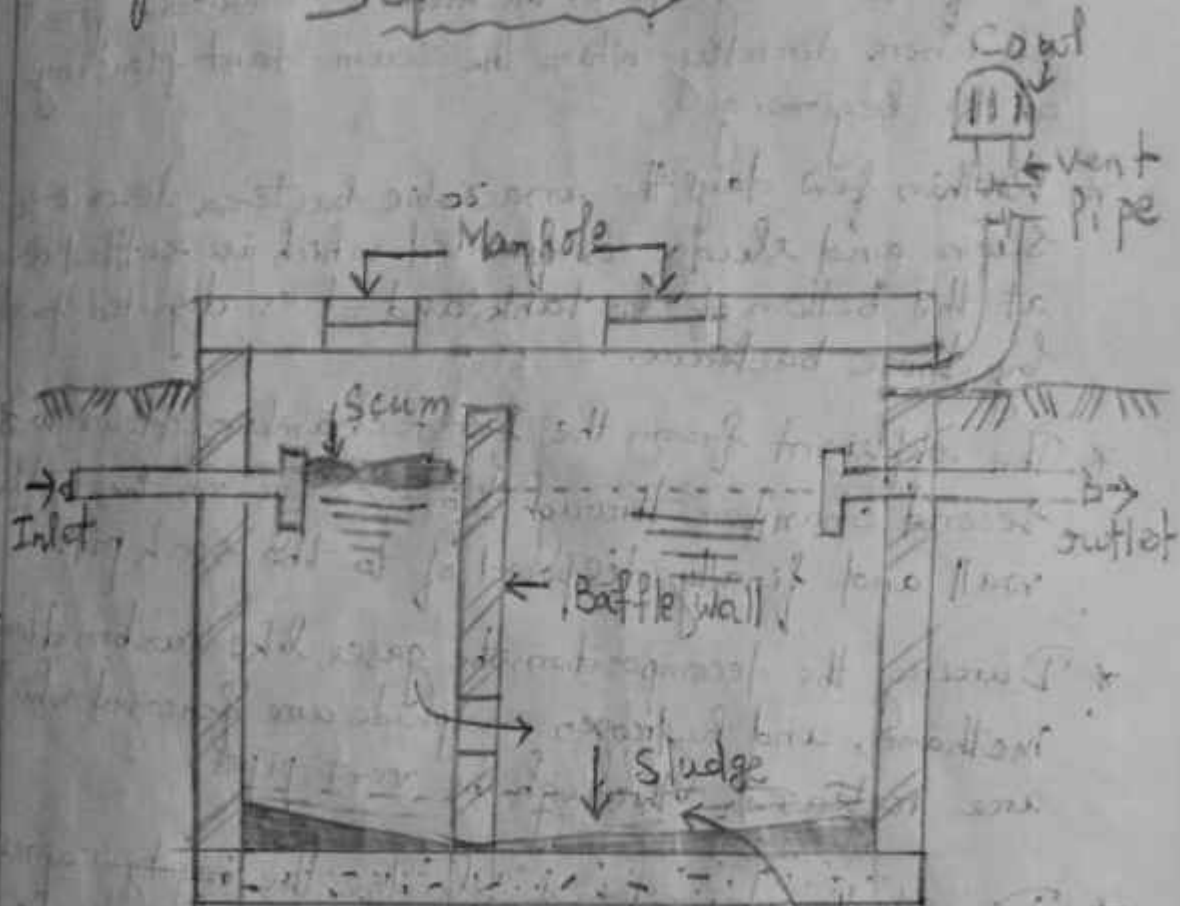
Constructional Features:-

The following are the constructional features of septic tank:-

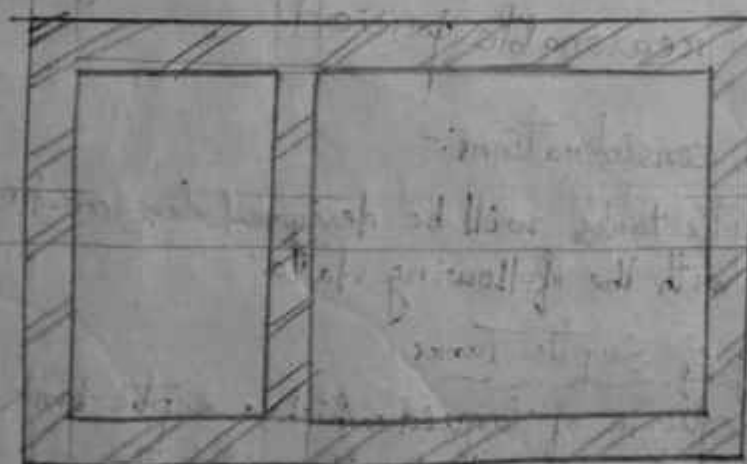
- (i) It is a rectangular tank constructed with brick masonry over concrete foundation. The length is usually 3 times the breadth.
- (ii) The liquid depth varies from 100-180cm.
- (iii) A free board of 30-50cm is provided above the liquid level.
- (iv) The inlet pipe and outlet pipe consist of 'T' or 'elbow' which are submerged to a depth of about 25cm below the liquid level.
- (v) The outlet level is about 15cm lower than the inlet level.
- (vi) The inside surface of the tank should be plastered and finished with neat cement polish to make it complete watertight.
- (vii) For smaller tank single baffle wall should be provided. But for larger tank two baffles should be provided near both the ends.
- (viii) The top of the baffle should be at least 15cm above the liquid level.
- (ix) Openings should be provided near the bottom of the baffle for the flow of effluent from first chamber to second chamber. Sometimes, hanging baffles may be provided.
- (x) R.C.C. slab with manholes is provided at the top of the tank.
- (xi) Ventilation pipe is provided for the removal of foul gases.

Working of

Septic Tank



SECTION OF SEPTIC TANK



PLAN OF SEPTIC TANK

Working of septic tank

- * The fresh sewage from the latrines enter the first chamber directly where the scum start floating at the beginning.
- * Within few days, the anaerobic bacteria decompose the scum and sludge is formed which is settled down at the bottom of the tank, and it is digested further by those bacteria.
- * The effluent from the first chamber flows to the second chamber through the openings in the baffle wall and finally disposed of to the soak pit.
- * During the decomposition, the gases like carbon dioxide, methane, and hydrogen sulphide are formed which are released through the vent pipes.
- * Due to the deposition of sludge, the capacity of the tank goes on reducing gradually. So the tank should be cleared every year or at some reasonable period.

Design considerations:-

The septic tanks will be designed like ordinary sedimentation tanks with the following data:

(i) Capacity of Septic Tanks

- * The volume of liquid which a septic tank can accommodate is called its capacity.
- * A septic tank should be capable of storing the sewage flow during the detention period, and an additional volume of sludge for 6 months to 3 years, depending upon the periodicity of cleaning.

- * If only water closets are connected to the septic tank, the sewage flow will be about 40-70 litres/capita/day
- * But when sullage is also discharged in to the septic tank, the sewerage flow may be as much as 90 to 150 litres/capita/day
- * Where a large quantity of sludge is expected, it may separately be disposed of in the manner as the effluent from the septic tank.
- * The sludge and the scum will accumulate in the tank at varying rates, depending upon the characteristics of raw sewerage, and the efficiency of the sedimentation and digestion. The rate of accumulation of sludge has been recommended as 30 litres/person/year.
- * The minimum capacity of a septic tank for about 8 to 10 persons, may be kept 2,250 litres (when all liquid wastes are discharged into the tank) and 1,400 litres (when only closet wastes are discharged.)

Free-board - A free-board of about 0.3-0.5m may be provided above the top sewage line in the tank. This will help accommodate the scum in the tank.

(ii) Inlet and outlet baffles, etc.

- * The baffles or tee should extend upto top level of the scum (about 20-22 cm above the top sewage line), but must stop a little below the bottom of the covering slab (by at least 7.5cm or so) so as to allow for the free-movement of gases.
- * Moreover, the inlet should penetrate by about 30cm below the top sewage line, and the outlet should penetrate to above about 40% of the depth of sewage.
- * Further, the outlet invert level should be kept 5 to 7.5cm below the inlet invert level.

(iii) Detention period:-

The detention period for a septic tank generally varies between 12 to 36 hours, but is commonly adopted as 24 hours.

(iv) Length to Width Ratio:-

Septic tanks are usually rectangular with their length at about 2 to 3 times the width.

The width should not be less than 90cm.

The depth of the tank generally ranges between 1.2 to 1.8m.

Problem related to volume calculation of septic tank

Q. Design the dimensions of a septic tank for a small colony of 150 persons provided with an assured water supply from the municipal head-works at a rate of 120 litres per person per day. Assume any data, you may need.

Soln:- The quantity of water supplied
= Per capita rate $\times$ Population
= 120×150 litres/day = 18,000 l/day

Assuming that 80% of water supplied becomes sewage, we have

The quantity of sewage produced
= $18,000 \times 0.8 = 14,400$ l/day.

Assuming the detention time to be 24 hours, we have

The quantity of sewage produced during the detention period (i.e., the capacity of the tank)

$$= 14,400 \times \frac{24}{24} = 14,400 \text{ litres.}$$

Now assuming the rate of deposited sludge as 30 litres/capita./year; and also assuming the period of cleaning as 1 year, we have

The volume of sludge deposited
 $= 30 \times 150 \times 1 = 4,500$ litres

$\therefore$ Total required capacity of the tank
 $=$ capacity of sewage + capacity for sludge
 $= 14,400 + 4,500 = 18,900$ litres $= 18.9 \text{ cu-m}$

Assuming 1.5m as the depth of the tank, we have
The surface area of the tank

$$= \frac{18.9 \text{ m}^3}{1.5} = 12.6 \text{ m}^2$$

If the ratio of the length to width is kept as 3:1, we have.

$$3 \cdot B^2 = 12.6$$
$$\text{or } B = \sqrt{\frac{12.6}{3}} = \sqrt{4.2} = 2.05 \text{ m; say } 2.1 \text{ m}$$

$\therefore$ Provided width = 2.1m; and
Provided length of the tank = 6m.

$\therefore$ Area of cross-section provided
 $= 6 \times 2.1 = 12.6 \text{ m}^2$ (same as required)

Thus, the dimensions of the septic tank will be
 $6 \text{ m} \times 2.1 \text{ m} \times (1.5 + 0.3) \text{ m}$ overall depth
[0.3m used as free-board]

Hence, use of a tank of size $6 \text{ m} \times 2.1 \text{ m} \times 1.8 \text{ m}$.
[Ans].

Q. Design a septic tank having the following data;

- i) Number of users - 200
- ii) Rate of water supply - 150 lit/head/day
- iii) Detention period - 18 hours
- iv) Percolating capacity of filter media - 1250 litres/m³

Also find the diameter of the soak well. Assume reasonable data, if required.

Soln:

Considering that the whole quantity of water comes as sewage

$$\text{Flow of sewage per day} = 200 \times 150 \\ = 30000 \text{ litres}$$

Detention period is 18 hours.

$$\text{So, Tank capacity} = \frac{30,000 \times 18}{24} = 22,500 \text{ litres}$$

Assuming sludge storage capacity at the rate of 20 litres/person/year.

$$\text{Volume of sludge} = 200 \times 20 \\ = 4000 \text{ litres}$$

$$\therefore \text{Tank capacity} = 22,500 \text{ litres} + 4000 \text{ litres} \\ = 26,500 \text{ litres}$$

Considering 20% provision for future extension

$$\text{Extra Volume} = 26,500 \times 0.2 = 5,300 \text{ litres}$$

$$\begin{aligned} \text{Total Volume of tank} &= 26,500 + 5,300 \\ &= 31,800 \text{ litres} \\ &= 32,000 \text{ litres (say)} \\ &= 32 \text{ m}^3 \quad [1 \text{ m}^3 = 1000 \text{ litres}] \end{aligned}$$

Considering, the effective depth of liquid as 1.5m

$$\text{Cross-sectional area} = \frac{32}{1.5} = 20.6 \text{ m}^2$$

Let, width = b .

and Length = $3b$.

$$b \times 3b = 20.6$$

$$\text{or } 3b^2 = 20.6$$

$$\therefore \cancel{b^2} = \frac{20.6}{3}$$

$$\therefore b = 3.0 \text{ m (say)}$$

$$\therefore \text{Length} = 3 \times 3 = 9 \text{ m}$$

Considering free board as 0.5 m

$$\text{Overall depth} = 1.5 + 0.5 = 2 \text{ m}$$

Therefore, the size of septic tank is $9 \text{ m} \times 3 \text{ m} \times 2 \text{ m}$.

Size of soak well

$$\text{Volume of soak well} = \frac{32 \times 1000}{1250} = 25.6 \text{ m}^3$$

[As Percolation Capacity = 1250
lits/m³]

Considering the depth of soak well as 3 m.

$$\text{Cross-sectional area} = \frac{25.6}{3} = 8.5 \text{ m}^2$$

Let d be the diameter of well.

$$\frac{\pi d^2}{4} = 8.5$$

$$\text{or } d = \sqrt{\frac{8.5 \times 4}{\pi}}$$

$$d = 3.2 \text{ m}$$

Therefore, the diameter of soak well is 3.2 m
and depth 3 m.

IMHOFF TANKS

* An imhoff tank is an improvement over septic tank, in which the incoming sewage is not allowed to get mixed up with the sludge produced and the outgoing effluent is not allowed to carry with it large amount of organic load as in the case of a septic tank.

* It is also known as Two-storey Digestion Tanks.

* It is a double chamber rectangular tank.

* The upper chamber is called the sedimentation chamber ^{or} ~~the~~ flowing through chamber through which the sewage flows at a very low velocity and the lower chamber is the digestion chamber in which the sludge gets digested due to anaerobic decomposition.

* In Imhoff tank, the sedimentation and digestion are carried out simultaneously. The following are the parts and working of Imhoff tank.

(a) Shape - It is circular in shape with hopper like bottom and constructed in R.C.C.

(b) Sedimentation chamber - As shown in Fig, it is the central zone of Imhoff tank. The sewage containing heavy sludge from the secondary clarifier is allowed to enter this chamber and is detained for specified period.

- (c) Baffle Plates and slots - The tank consists of baffle plates with hopper like bottom. Slots are provided between the baffle plates and the body of the tank. The sludge is gradually settled down through the slots and deposited in the digestion chamber.
- (d) Digestion chamber - This is the lower part of the Imhoff tank. In this chamber, the sludge is digested under anaerobic ~~condif~~ condition.
- (e) Neutral zone - The space between the slot and the top of digestion chamber is known as neutral zone. The depth of this zone is generally 30m. This zone prevents the entry of digested sludge into the sedimentation chamber.
- (f) Gas Chamber - It is the upper zone of the Imhoff tank. In this chamber, the gases (mainly methane) are collected which are withdrawn and used as fuel.
- (g) Sludge Removal :- The digested sludge from the digestion tank is withdrawn through the sludge removal pipe and taken to the drying bed.

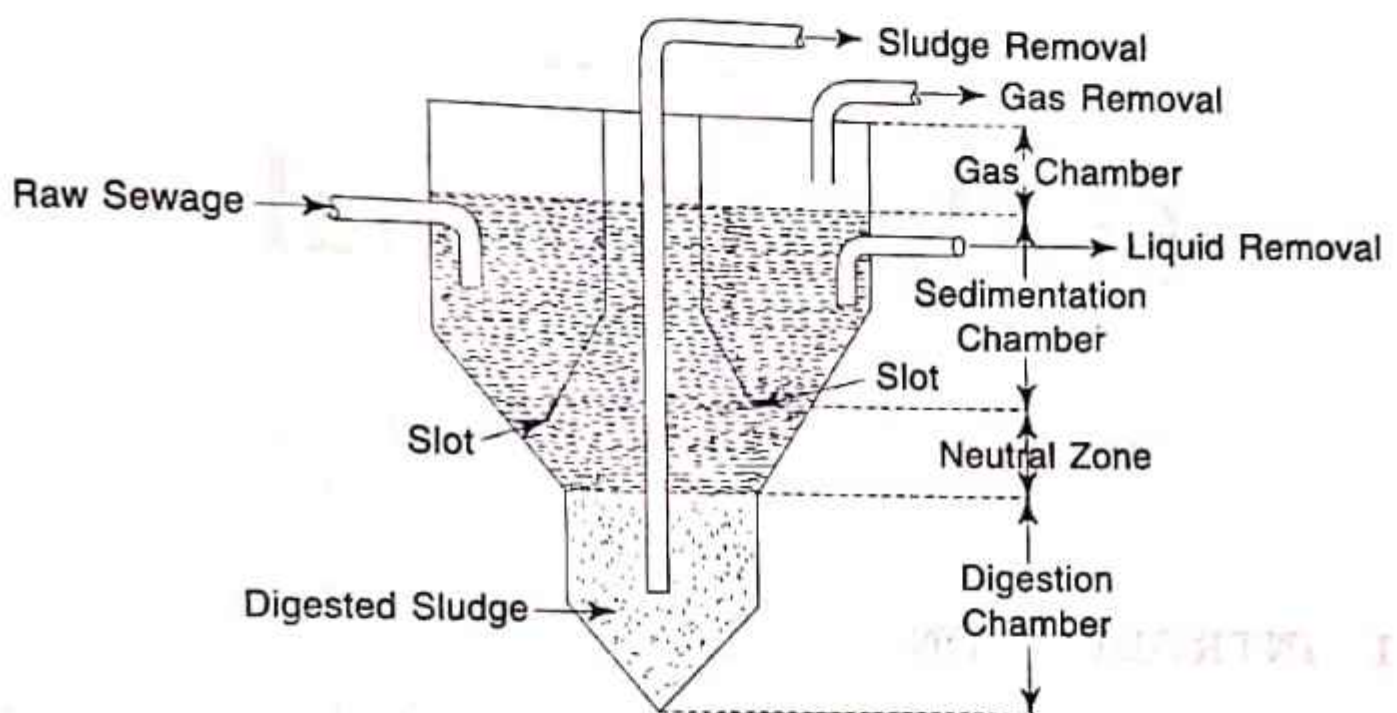


Fig. 12.2 Imhoff tank

SANITATION

Sanitation:

* Sanitation generally refers to the provision of facilities and service for the safe disposal of human urine and faeces.

* The word 'sanitation' also refers to the maintenance of hygienic conditions, through services such as garbage collection and wastewater disposal.

State the importance of sanitation in relation to public health.

- * In every town or city, wastes of different types such as spent water from bath room, kitchen, 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 produced daily.
- * If proper arrangements for the collection, treatment and disposal of all the wastes produced from the town or city are not made, they will go on accumulating and create such a foul condition that the safety of the structures such as buildings, roads will be in danger due to accumulation of spent water in their foundations.
- * In addition the disease bacteria will breed up in the stagnant water and the health of the public will be in danger.
- * All the drinkable water will be polluted. Total insanitary conditions will be developed in the town and it will become impossible for the public to live in the towns or cities.

- * Therefore in the interest of community of the town or city, it is most essential to collect, treat and dispose of all the waste products of the city in such a way that it may not cause any havoc to the people residing in the town.

Definitions of some common terms used in Sanitary Engineering

(i) Anti-siphonage Pipe:

A pipe which is installed in the house drainage to preserve the water seal of traps is known as anti-siphonage pipe. It maintains proper ventilation and does not allow the siphonic action to take place.

(ii) Siphonage:

Water seal of traps may break due to siphonic action. This is known as 'siphonage' and it is induced when water is suddenly discharged from a fixture on the upper floor.

(iii) Soil Pipe:

The term soil pipe is used to indicate the pipe which carries discharges from soil fittings such as urinals, water closets, etc.

(iv) Vent Pipe:

The pipe installed for the purpose of ventilation is known as vent pipe.

(v) Waste Pipe:

The term waste pipe is used to indicate the pipe which carries discharges from sanitary fittings such as bathrooms, kitchens, sinks, etc.

(vi) Invert:

The lowermost level or surface of a sewer is known as its invert.

(vi) Refuse:

The term 'refuse' is used to indicate what is rejected or left as worthless and for the study of sanitary engineering, it is divided into five categories:

- (a) Garbage
- (b) Sewage
- (c) Storm water
- (d) Subsoil water
- (e) Sullage
- (f) Rubbish

(a) Garbage: The term garbage is used to indicate ~~what is rejected or left as worthless~~ dry refuse and it includes decayed fruits, grass, leaves, paper pieces, sweepings, vegetables etc.

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

Combined sewage: This indicates a combination of sanitary sewage and storm water with or without industrial waste.

Crude or Raw Sewage: This indicates the sewage that is not treated.

Domestic or Sanitary sewage: This indicates sewage mainly derived from residential or business buildings, institutions, etc.

Fresh sewage: This term is used to indicate the sewage which has been recently originated or produced.

Septic sewage: This indicates sewage which is undergoing the treatment process.

- (c) Storm water: The term storm water is used to indicate the rainwater of the locality.
- (d) Subsoil water: This indicates the groundwater, which finds its entry into sewers through leaks.
- (e) Sullage: The term sullage is used to indicate the waste water from bath rooms, kitchens, etc.
- (f) Rubbish: All sundry solid wastes as papers, broken furnitures, pottery, waste building materials, etc. are known as rubbish.
- (viii) Sewer: The underground conduits or drains through which sewage is conveyed are known as sewers.

Main Sewer:-

The sewer which carries the whole sewage coming from the branch lines is termed as main sewer.

Branch or Submain sewer:-

The sewer which carries or obtains its discharge from the lateral sewers and delivers it to the main sewer is termed as branch or submain sewer.

Combined Sewer:-

The sewer which carries domestic sewage and stormwater is known as combined sewer.

Common Sewer:-

The sewer on which all the inhabitants have equal legal rights is known as common sewer.

Depressed Sewer:-

When an obstruction or obstacle is met with, the sewer is constructed lower than the adjacent sections to overcome the obstruction or obstacle. Such a portion or section of sewer is known as 'depressed sewer'.

Intercepting Sewer:-

This term is used to indicate the sewer which intercepts the discharge from a number of main or outfall sewers, and it carries the flow to the point of treatment and disposal.

Lateral Sewers:-

The sewer obtaining its discharge directly from buildings is known as 'Lateral sewer'.

Main Sewer:-

The sewer which obtains its discharge from a few branch or submain sewers, is known as main sewer.

Outfall sewer:-

The length of main or trunk sewer between the connection of lowest branch and final point of disposal, is known as outfall sewer.

Relief or overflow sewer:-

The sewer which is meant to carry the excess discharge from an existing sewer is known as relief sewer.

Trunk Sewer:-

The sewer which obtains its discharge from two or more main sewers is known as a trunk sewer.

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

Refuse collection

For the disposal of waste products of a town two works are required:

- (i) Collection works
- (ii) Disposal works.

- * The collection works are the works which are done to collect the waste products.
- * The disposal works mainly consist of treatment works which are essential to treat the 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 waste sources.

Methods of collection

The sanitation of a town or city is done by two methods, which are:-

- (a) Conservancy System
- (b) Water-Carriage System.

CONSERVANCY SYSTEM

- * Sometimes this system is also called dry-system.
- * It is prevailing in small towns, villages and underdeveloped portions of the large cities.
- * Various types of refuse and storm water are collected conveyed and disposed off separately by different methods in this system, therefore, it is called conservancy system.
- * Garbage and 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 the further development of the town.

- * The combustible portions of garbage such as dry leaves, waste paper, broken furniture, etc. are burnt.
- * The decaying fruits and vegetables, grass and other such things are first dried and then disposed of by burning or in the manufacture of manure.
- * Human Excreta or Night Soil is collected separately in privies or conservancy latrines. The liquids and semi-liquid wastes are collected in separate drains of the same latrine, from where they are removed through human agency.

After removal, night soil is taken outside the town in closed animal drawn carts, trucks, etc. The night soil is buried in trenches. After 2-3 years, the buried night soil is converted into an excellent manure which can be used for

- * ^{growing crops.} ~~The sullage and storm waters are carried separately in closed or open drains.~~ MERITS OF CONSERVANCY SYSTEM

The following are the merits of conservancy system:-

- (i) It is cheaper in initial cost because stormwater can pass in open drains and conservancy latrines are much economical.
- (ii) The quantity of sewage reaching at the treatment plant before disposal is low.
- (iii) 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.
- (iv) In floods if the water level of river rises at the out-fall, it will not be costly to pump the sewage for disposal.

DEMERITS OF CONSERVANCY SYSTEM

The following are the demerits of conservancy system:

- (i) It is possible that storm water may go in sewers causing heavy load on treatment plants, therefore it is to be watched.
- (ii) In crowded lanes it is very difficult to lay two sewers or construct roadside drains causing great inconvenience to the traffic.
- (iii) For burying human excreta more space of land is required.
- (iv) Buildings cannot be designed as one compact unit because latrines are to be provided away from the living rooms due to foul smell, which are also inconvenient.
- (v) There is every possibility that liquid refuse may get an access in the subsoil and pollute the underground water.
- (vi) In the presence of conservancy system, the aesthetic appearance of the city cannot be increased.
- (vii) Decomposition of sewage causes insanitary conditions which are dangerous to public health.
- (viii) This system completely depends on the mercy of sweepers at every time. If the sweepers go on strike, there is every possibility of the spreading of diseases in the town due to decomposition of foul matters.

WATER-CARRIAGE SYSTEM

- * As in this system, water is the main substance, therefore it is called Water-Carriage System.
- * In this system the excremental matters are mixed up in 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 percent of water and the remaining 0.1 percent of solid matters.
- * All these solids remain in suspension in the sewage and do not change the specific gravity of the water, therefore all the hydraulic formulae can be directly used in the designing of sewage systems and the treatment plants.

MERITS OF WATER CARRIAGE SYSTEM

- ② The following are the merits of water carriage system:-
- (i) It is hygienic method, because all the excremental matters are collected and conveyed by water only and no human agency is employed for it.
 - (ii) There is no nuisance in the streets of the towns due to offensive matters, because all the sewage goes in closed sewers under the ground. The risk of epidemics is reduced.
 - (iii) As only one sewer is laid, therefore it occupies less space in crowded lane.
 - (iv) Due to more quantity of sewage, self-cleansing velocity can be obtained even at less gradients.

- (v) Buildings can be designed ~~as~~ compact as one unit.
- (vi) The land required for the disposal work is less as compared with conservancy system in which more area is required for burying the excremental matters.
- (vii) The usual water supply is sufficient and no additional water is required in water-carriage system.
- (viii) This system does not depend on manual labour at every time except when sewers get choked.
- (ix) Sewage after ~~the~~ proper treatment can be used for various purposes.

DEMERITS OF WATER CARRIAGE SYSTEM

The following are the demerits of water-carriage system:

- (i) This system is very costly in initial cost.
- (ii) The maintenance of this system is also costly.
- (iii) 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 SYSTEMS

The sewerage systems are classified as follows:-

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

(a) Combined system:- When only one set of sewers is laid, carrying both the sanitary sewage and storm water, it is called combined system.

(b) Separate system:- When the domestic and industrial sewage are taken in one set of sewers, whereas storm and surface water are taken in another set of sewers, it is called separate system.

(c) Partially separate 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.

* The combined system can also be suited in areas having less sewage, to obtain the self-cleaning velocity.

* 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 years.

* In rocky areas it is more expensive to lay one large sewer than two small sewers. Separate systems should be provided if the sanitary sewage is to be pumped.

MERITS AND DEMERITS OF SEPARATE SYSTEM

Following are the merits of separate system:-

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

Following are the demerits of separate system:-

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

MERITS AND DEMERITS OF COMBINED SYSTEM.

Following are the merits of combined system:

- (i) There is no need of flushing, because self-cleaning velocity is easily available at every place due to more quantity of sewage.
- (ii) Rain water dilutes the sewage, therefore it can be easily and economically treated.
- (iii) House plumbing can be done easily because only one set of pipes will be required.

Following are the demerits of combined system:

- (i) Initial cost is higher, as compared with separate system.
- (ii) It is not suitable for areas having rainfall for smaller period of the year, because the dry-weather flow will be small due to which self-cleaning velocity will not be available resulting in the silting up of the sewers.
- (iii) If the whole sewage is to be disposed off by pumping, it is uneconomical.
- (iv) During heavy rains, the overflowing of sewers will endanger the public health.
- (v) In congested areas, it is easy to lay one larger sewer than two smaller sewers.

MERITS AND DEMERITS OF PARTIALLY SEPARATE SYSTEM

Following are the merits of partially separate system:

- (i) As it is an improvement over separate system, economical and reasonable size sewers are required.
- (ii) The work of house-plumbing is reduced, because the rain water from roof, sullage from baths and kitchen etc, can be taken in the same pipe carrying the discharge from the water closets. The water from all other places can be taken in separate sewer or drains.
- (iii) No flushing is required, because the quantity of sewage is increased as small portion of storm water is allowed to enter in sanitary sewage.

Following are the demerits of partially separate system:

- (i) The cost of pumping is ~~re~~ increased at disposal plants than separate system because a portion of storm water is mixed with sanitary sewage.
- (ii) There are possibilities of over-flow, requiring storm-overflows.
- (iii) In dry weather, the self-cleaning velocity may not develop.