Swami Keshvanand Institute of Technology Management & Gramothan Jaipur

ENVIRONMENTAL ENGINEERING AND DISASTER MANAGEMENT

SUBJECT CODE: 7AG6-60.2

SEMESTER: VII (OPEN ELECTIVE – I)

UNIT-: IV-DOMESTIC WASTE WATER

CONTENT

- **Domestic waste water:-Quantity and characteristics.**
- **Domestic waste water:- Disposal in urban and rural areas.**
- **Sewer:- types, design discharge and hydraulic design.**
- **Introduction to domestic wastewater treatment.**

Domestic waste water

Domestic waste water

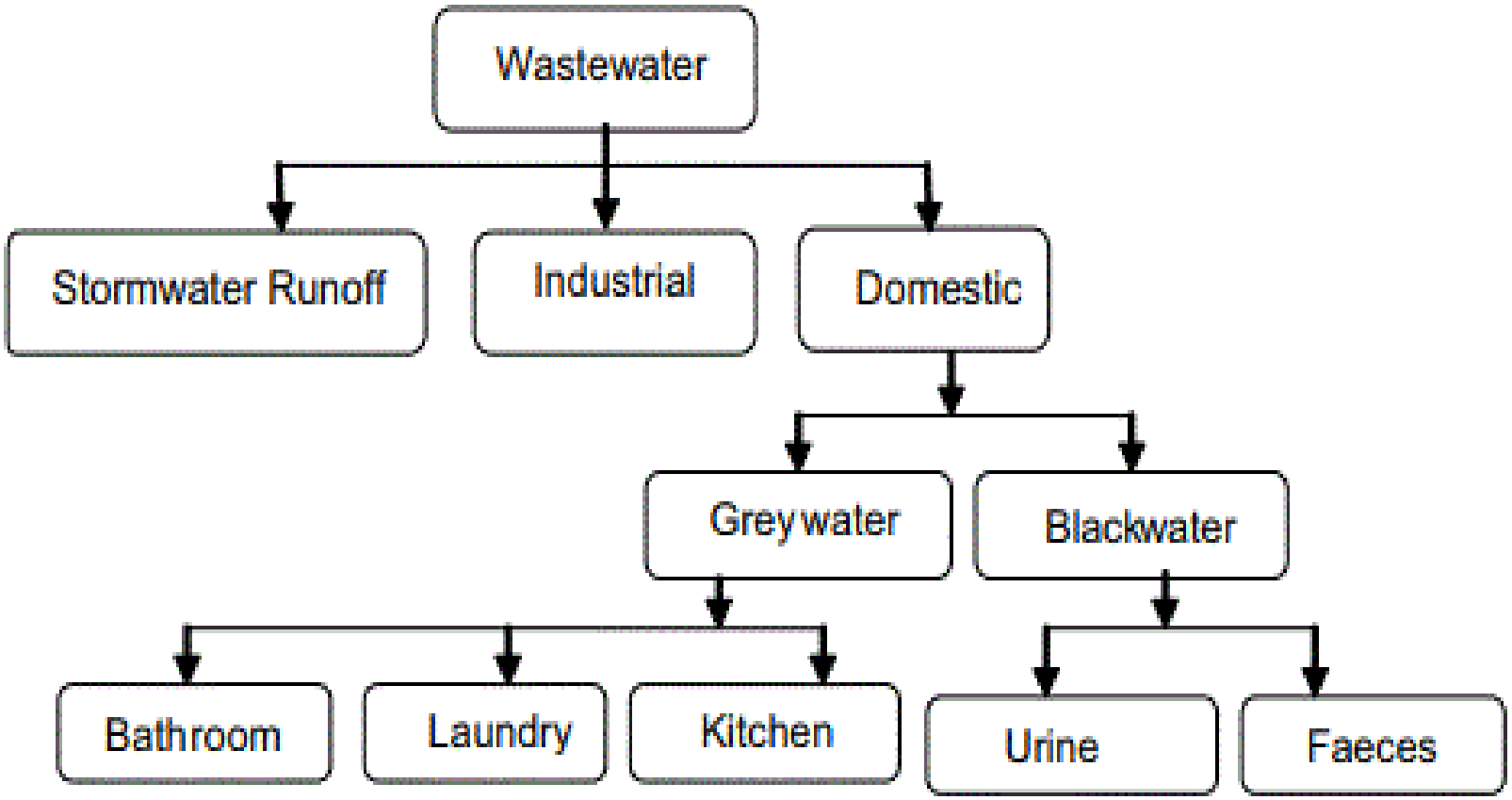
- Quantity and Characteristics
- Disposal in urban and rural areas

Domestic waste water

Wastewater

- Any liquid that contains impurities or pollutants in the form of solids or gasses or their combinations in such a concentration that is harmful if disposed into the environment
- Wastewater is the water which is disposed from homes, offices and industry.
- It comes from toilets, sinks, showers, washing machines and industrial processes and was historically called sewage.

Domestic waste water



Domestic Waste Water

- Wastewater produced due to human activities in households is called domestic waste water i.e. wastewater from the kitchen, shower, wash basin, toilet and laundry

Domestic waste water – Quantity

Quantity= Per capita sewage contributed per day x Population

The sewage (Waste Water) consists of the following two categories:

1. Dry weather flow
2. Storm water

1.DRY WEATHER FLOW

This is sometimes written as D.W.F. and it consists of two types of sewage:

(1)Domestic or sanitary sewage (2)Industrial sewage

The quantity of D.W.F. is determined by considering the following four factors:

1.Infiltration and exfiltration 2.Nature of industries

3.Population 4.Rate of water supply

Domestic waste water – Quantity

Infiltration and exfiltration

The term infiltration is used to indicate the leakage of water from the ground surrounding the sewer and the term exfiltration is used to indicate the leakage of sewage from the sewer into the ground surrounding the sewer.

The infiltration and exfiltration are both undesirable. The infiltration unnecessarily increases the quantity of sewage. The exfiltration pollutes the underground sources of water, if any. The infiltration, however, is preferred to exfiltration.

The infiltration and exfiltration can be prevented to some extent by constructing watertight joint of sewers.

The quantity of water through infiltration depends on the following four factors:

- Head of subsoil water level
- Length of sewer
- Nature and type of soil through which sewer is laid and Size of sewer

Domestic waste water – Quantity

Nature of industries

The quantity of industrial sewage will depend upon the nature of industries.

Population

The design period of different parts of the sewerage system is different.

Following factors are taken into account while fixing the probable life of a particular part of the sewerage system-

- Chances of improvement in the equipment
- Cost of adding an extra unit of the equipment
- Labour conditions having important influence on the cost of equipment
- Operation methods
- Original cost of the part

Domestic waste water – Quantity

Usually, the design periods of the following parts of sewerage system are:

- Laterals: These are designed for 50 years or so
- Branches and sub mains: These are also designed to last for 50 years or more
- Main sewers and trunk sewers: These are designed for 30 to 50 years
- Pumping plant: As additional pump can be installed with short notice, the design period of pumping plant is about 5 to 10 years.
- Treatment units: These are designed for 10 to 30 years.

Domestic waste water – Quantity

Rate of water supply

- Usually the quantity of water entering the sewer will be slightly less than the quantity of water supplied.
- For practical purposes, the rate of sewage is assumed as equal to the rate of water supply.

Following two factors should be considered while comparing rate of sewage with rate of water supply.

1. Intensity of pressure: If water is supplied at high pressure, there is more consumption of water and more wastage of water from leakage in pipes, valves etc.
2. Use of water: It is quite likely that water which is supplied may not appear as sewage after its consumption.

For e.g. water that is supplied to fill up the tanks of railway locomotives will not appear as sewage. Similarly, the quantity of water supplied and the quantity of sewage formed by various prominent industries such as cotton mills, milk plants, etc. should be studied and accordingly the rate of sewage should be decided.

Domestic waste water – Quantity

STORM WATER-Surface water in abnormal quantity resulting from heavy falls of rain or snow.

Wherever possible, the storm water is to be collected and conveyed in sewers at proper places for the following reasons:

- Damp conditions are created which are unhygienic as they provide flourishing ground for micro organisms
- Existence of water pools affects the foundations of structures
- Initial washings of streets by storm water contain organic matter and hence such water requires to be collected and to be taken to the treatment plant
- Low lying areas get flooded and transport system is paralysed. It leads to loss of revenue.

Domestic waste water – Quantity

- The quantity of storm water, which is known as wet weather flow and mentioned as W.W.F., that will enter sewer is to be carefully determined.
- It involves various factors such as intensity of rainfall, characteristics of catchment area, duration of storm, etc.
- Following two methods are generally employed for calculating the quantity of storm water for the purpose of designing sewers:

1.Rational method

2.Empirical method

Domestic waste water – Quantity

1.Rational method

In this method, the following three factors are combined in the form of an equation:

$Q = K I A / 360$

Where,

Q = peak runoff in m^3 per second

K = Impermeability factor

I = Intensity of rainfall, mm per hour

A = Area in hectares

Catchment area-The catchment area to be served by a storm water sewer is measured directly form the map of the locality

Domestic waste water – Quantity

Impermeability factor

Some quantity of rain water that falls on the ground is absorbed by soil and the percentage of rain water that enters the sewer is known as impermeability factor.

Intensity of rainfall

The intensity of rainfall can be worked out from the rainfall records of the area under consideration. Where rainfall records are not available, the intensity of rainfall is obtained by applying suitable empirical formula.

Domestic waste water – Quantity

2.Empirical method

The general empirical formula adopted to calculate intensity of rainfall is:

$$R=25.4\ a/t + b$$

Where, R = Intensity of rainfall in mm per hour

t = Duration of storm in minutes

a and b are constants

The values of a and b are as follows:

a = 30 and b = 10 when duration of storm is 5 to 20 minutes

a = 40 and b = 20 when duration of storm is 20 to 100 minutes

Domestic waste water – Quantity

(b) For localities where rainfall is frequent:

i=Intensity of rainfall in mm per hour $i = \frac{3430}{t+18}$ where i and t are as above.

This formula is adopted for area having heavy and frequent rainfall. It gives intensity of rainfall which will occur once in 5 yrs. or so.

(c) For storms occurring once in 10 yrs.:

$$i = \frac{180}{\sqrt{t}}$$

(d) For storms occurring once in a year: $i = \frac{150}{t^{0.62}}$ where i and t are as above

(e) Kuichling's formula:

$i = \frac{2667}{t+20}$ for storms occuring once in 10 yrs.

$i = \frac{3048}{t+20}$ for storms occuring once in 15 yrs.

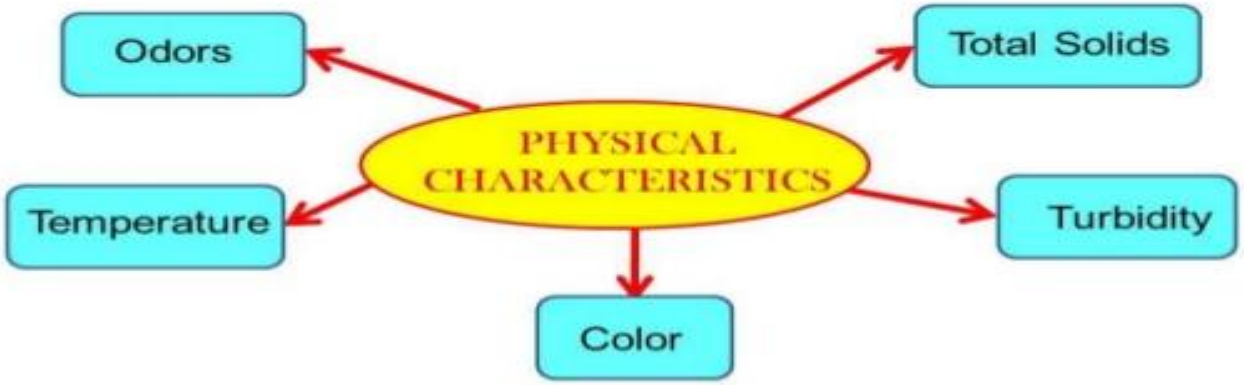
Characteristics of Sewage / Waste water

The Characteristics of sewage arc classified as follows:

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

Characteristics of Sewage / Waste water

1. Physical characteristics



Characteristics of Sewage / Waste water

- **Color** : Color is due to the suspended and other matters found in wastewater. If sewage is fresh it has a soap solution colour i.e. grey-brown and decomposed sewage has dark grey colour.
- **Odour:** Fresh sewage is of soapy or oily odour but stale sewage has offensive odour due to H2S, CH4.
- **Temperature:** Generally sewage has slightly higher temperature than the water which increases the biological activities. 40 degree C.
- **Turbidity :** It is very turbid than water due to the presence of high suspended and other Solids : 350-1200 mg/L
- **Total solids-** Though sewerage typically contains lower than zero to 0.5 % solids, the remainder being water. The sewerage solids could also be classified into dissolved solids, suspended solids and volatile suspended solids.

Characteristics of Sewage / Waste water

2.Chemical Characteristics

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

• pH

• DO (Dissolved Oxygen)

• BOD (Biochemical Oxygen Demand)

• COD (Chemical Oxygen Demand)

Characteristics of Sewage / Waste water

pH

- The pH scale of the contemporary sewerage is slightly quite the water provided to the community.
- 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.

Characteristics of Sewage / Waste water

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

Characteristics of Sewage / Waste water

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/100㎖)	2,200	out of analysis
Heterotrophic Plate Count (number/100㎖)	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

Characteristics of Sewage / Waste water

3.Biological characteristics

- Sewage contains bacteria and other living micro-organisms such as algae, fungi, protozoa, etc.
- Domestic sewage consists of various types of plant or animal microorganism.
- This microorganism whose presence is 22 — 25 millions numbers in a litre of sewage may be pathogenic, indicator organisms etc.
- Bacteria are present in sewage in large number and pathogenic bacteria are harmful and they are responsible for causing diseases.
- Sewage obtains such bacteria from the discharges of persons and animals suffering from various diseases. and harmful to man.
- The major part of bacteria in sewage is engaged in carrying out the process of breaking the complex organic compounds into simple and stable compounds which may be organic or inorganic

Characteristics of Sewage / Waste water

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.

Characteristics of Sewage / Waste water

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

Disposal of domestic waste water in rural and urban areas

- **Sewage**: liquid waste from community
- Removing act of sewage :**Sewage disposal**

Necessity

- Accumulation causes nuisance
- Selection of Pre-treatment method
- Protection of groundwater

Objectives

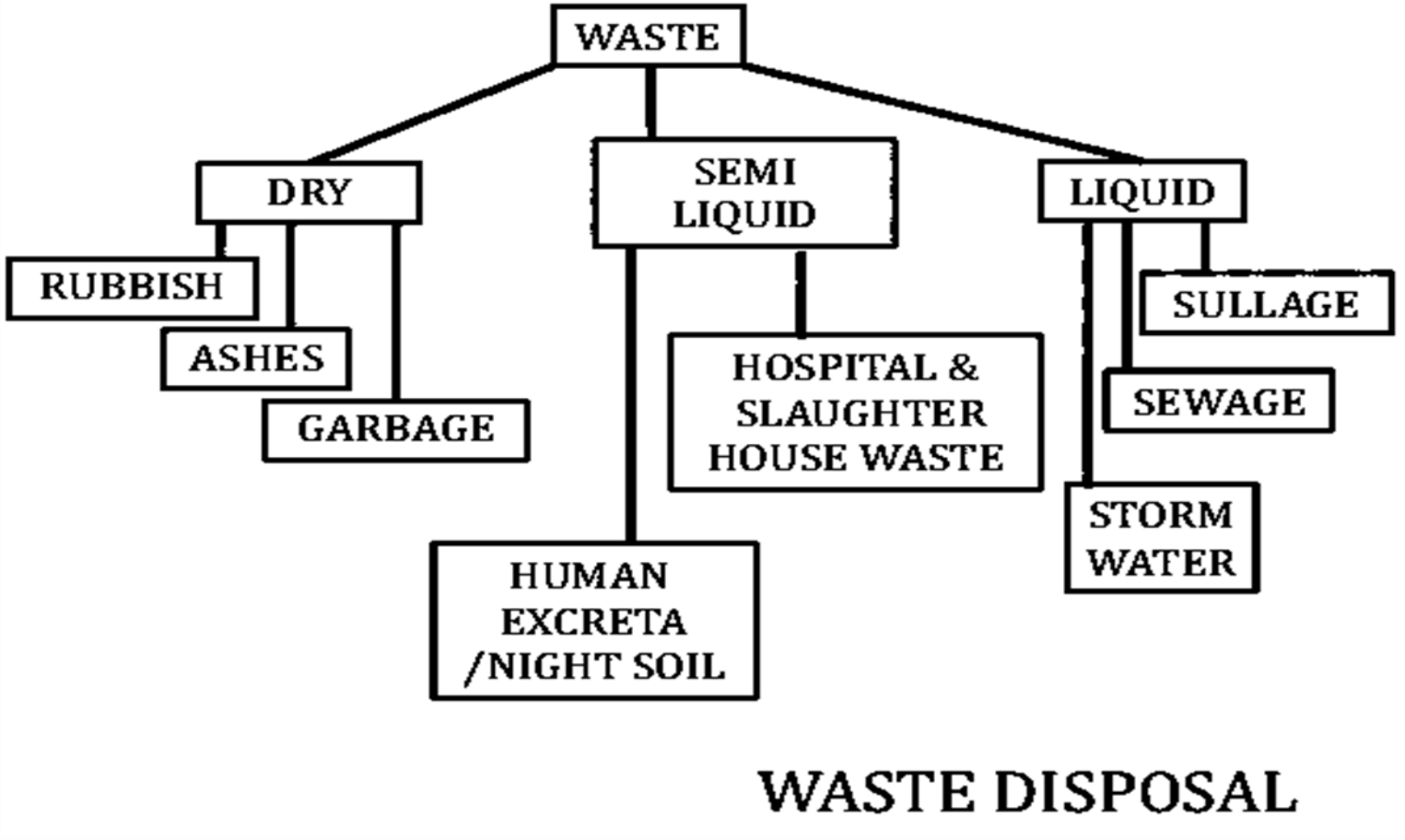
- To improve public health
- To use sewage in farm
- To protect aquatic life

Disposal of domestic waste water in rural and urban areas

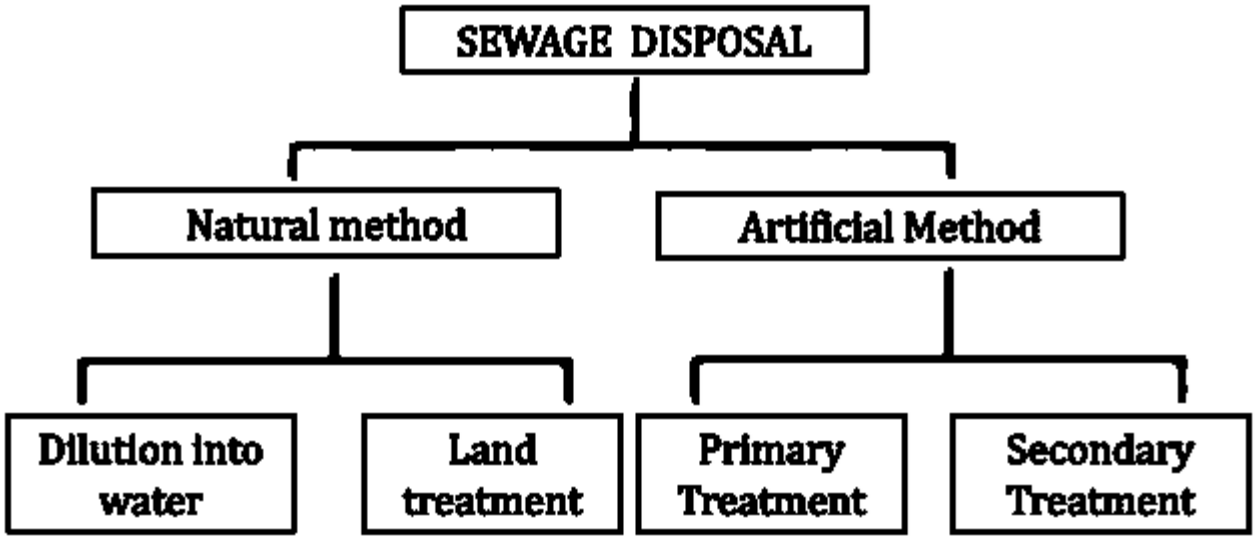
The methods of sewage disposal can classified as follows:

- Disposal by dilution
- Disposal by land treatment

Disposal of domestic waste water in rural and urban areas



Disposal of domestic waste water in rural and urban areas



SEWAGE DISPOSAL

Disposal of domestic waste water in rural and urban areas

Disposal by dilution

- In this process, the raw sewage or the partially treated sewage is thrown into natural waters having large volume.
- The sewage in due course of time is purified by what is known as the self-purification capacity of natural waters.

Conditions favourable for dilution

- It is possible only to provide primary treatment to sewage i.e., removal of floating matter and settle able solids.
- Currents of flow of diluting waters should be favourable which means that nuisance should not be caused when sewage is discharged into diluting waters.

Disposal of domestic waste water in rural and urban areas

- Diluting waters are not used for the purpose of navigation for at least some reasonable distance on the downstream from the point of sewage disposal.
- Diluting waters should not have habitation or they should not have been used as source of water supply for at least some reasonable distance on the downstream from the point of sewage disposal.
- Dissolved oxygen content of diluting waters should be high.
- The place is situated near natural waters having large volumes.
- The sewage is relatively fresh and it is possible to bring it to the point of discharge within four or five hours of its production.

Disposal of domestic waste water in rural and urban areas

Types of natural waters

Following are the natural waters into which the sewage can be discharged for dilution

- Creeks
- Estuaries
- Ground waters
- Lakes
- Ocean or sea
- Perennial rivers and streams

Disposal of domestic waste water in rural and urban areas

Self purification of natural waters

- When sewage is discharged into natural water, its organic matter gets oxidized by the dissolved oxygen content in water.
- The oxidation of organic matter converts such matter into simple inoffensive substances.
- Deficiency of dissolved oxygen thus created in natural waters is filled up by the absorption of atmospheric oxygen.
- Thus, the oxygen of water is consumed by sewage and at the same time, it is replenished by the atmosphere.
- This phenomena which occurs in all natural waters is known as self-purification of natural waters.
- The rate of self-purification will depend on various factors such as rate of re-aeration type of organic matter present in sewage, temperature, velocity of flow, presence of available oxygen in receiving waters, sedimentation, etc.

Disposal of domestic waste water in rural and urban areas

Disposal by land treatment

- The raw domestic waste water (sewage) is applied on the land.
- A part of sewage evaporates and the remaining portion percolates through the ground and is caught by the underground drains for disposal into natural waters.
- The sewage adds to the fertilizing value of land and crops can be profitably raised on such land.
- The term sewage farming is also sometimes used for indicating disposal of sewage by land treatment.
- The design of a good land treatment system demands the services of environmental engineers, hydraulic engineers, irrigation engineers, agronomists, soil scientist, etc.

Disposal of domestic waste water in rural and urban areas

Conditions favourable for land treatment

- The area of land treatment is composed of sandy, loamy or alluvial soils. Such soils are easily aerated and it is easy to maintain aerobic conditions in them
- The depth of water table is more even in rainy season so that there are no chances of pollution of underground water sources by land treatment
- The rainfall in the area is low as it will assist in maintaining good absorption capacity of soil
- There is absence of river or other natural water sources in the vicinity of disposal of sewage
- There is demand for cash crops which can be easily grown on sewage farms
- There is availability of large open areas in the surrounding locality for practicing broad irrigation by sewage

Disposal of domestic waste water in rural and urban areas

Advantages of land treatment

- It increases the fertility of land.
- It is cheap where land is available in plenty.
- Application of sewage on land is the best method of supplying manure to the soil.
- Crops grown on land treated with sewage possess high calorific value and more vitamins.
- Increased fertility of land results in profitable returns of crops.
- The method becomes very much useful at places where disposal of sewage by dilution is not possible.
- The method does not require costly equipment for its working

Disposal of domestic waste water in rural and urban areas

Disadvantages of land treatment

- If proper precautions are not taken, nuisance developed by sewage farming may lead to possible dangers to the health of men. It is therefore, necessary that the sewage farms should be operated under skilled technical supervision
- Crops grown on sewage farms are generally not liked by ordinary public.
- The method is not applicable for all the seasons of year. In monsoon, some other arrangement of sewage disposal has to be found out.
- The method requires large area of land which may not be available in some cases
- Types of crops grown on sewage treated land are limited in number.

Disposal of domestic waste water in rural and urban areas

Sewage sickness

- If sewage is applied continuously on a piece of land, pores or voids of soil are filled up or clogged.
- Free circulation of air is thereby prevented and anaerobic conditions develop.
- At this stage, the land is unable to take any further sewage load.
- Organic matter decomposes and foul smelling gases are produced.This phenomena of soil is known as sewage sickness of land.

Disposal of domestic waste water in rural and urban areas

Preventive measures of sewage sickness of land

Alternative arrangement: There should be ample provision of extra land so that land with sewage sickness can be given the desired rest. Alternatively, sewage should be disposed off by some other method when sewage farms are taking rest.

Depth of sewage: If sewage is applied in excess, the chances of sewage sickness are increased. The land is unable to receive the excess sewage in a satisfactory way and it ultimately clogs up. Depth of sewage on land should be decided by keeping in view the climatic conditions, drainage facilities, nature of crops and characteristics of soil.

Drainage of soil: Subsoil drain pipes should be laid in sufficient number to collect the percolated effluent.

Disposal of domestic waste water in rural and urban areas

Intermittent application: Sewage should be applied on land at intervals. Depending on the nature of the soil, this period between successive applications varies from few hours to few weeks.

Pre-treatment of sewage: Sewage should be given some pre-treatment before it is applied on land.

Rotation of crops: It is desirable to grow different types of crops on a piece of land instead of one single crop

Treatment to land: The land affected by sewage sickness should be properly treated before it is put up in use again.

Sewer:- Types, design discharge and hydraulic design

Sewage

It is Liquid Waste or Waste Water produce as a result of water use.

Sewer

It is the pipe or conduit for carrying sewage. It is generally closed and flow takes place under gravity (Atmospheric Pressure).

Sewerage

Sewerage is the system of collection of waste water and conveying it to a point of final disposal with or without treatment.

Sewer:- Types, design discharge and hydraulic design

Sewers are underground pipes which carry sewage to the point of discharge or disposal.

Important points to be considered before selecting sewer material-

Strength and durability-The sewer should have sufficient strength to withstand all the forces that are likely to fall on them.

The material selected should be durable and should have sufficient resistance against natural weathering action to provide longer life to the pipe.

Resistance to abrasion

Sewage mostly contains grit. These particles moving at high velocity can cause wear and tear of sewer material. This abrasion can reduce thickness of pipe and reduces hydraulic efficiency of the sewer by making the interior surface rough. Therefore, the material of the sewer should be in a position to offer enough resistance to abrasion.

Sewer:- Types, design discharge and hydraulic design

Resistance to corrosion-Sewer carries wastewater that releases gases such as H2S. This gas in contact with moisture can be converted in to sulphuric acid. The formation of acids can lead to the corrosion of sewer pipe. Hence, selection of corrosion resistance material is needed for long life of pipe.

Weight-To facilitate easy handling and transportation, the sewers should have less specific weight.

Imperviousness-To eliminate chances of sewage exfiltration and infiltration, the material selected for pipe should be impervious.

Cost-Sewer should be less costly to make the sewerage scheme economical.

Hydraulically efficient-The sewer shall have smooth interior surface to have less frictional coefficient

Sewer:- Types, design discharge and hydraulic design

Materials for sewer

(1)Asbestos Cement Sewers

For example, transport of rainwater from roofs in multi-storeyed buildings, for transport of sewage to grounds, and for transport of less foul sullage i.e., wastewater from kitchen and bathroom.

(2) Plain Cement Concrete or Reinforced Cement Concrete

Cement concrete pipes may be used for surface water drains in all diameters.

(3)Brick Sewers

They are used for construction of large size sewers or particularly for storm water drains.

(4)Galvanized iron sewers-Corrugated iron sewers are used for storm sewers.

Sewer:- types, design discharge and hydraulic design

(5)Cast Iron

- Cast iron pipes are used for outfall sewers, rising mains of pumping stations, and inverted siphons, where pipes are running under pressure.
- These are also suitable for sewers under heavy traffic load, such as sewers below railways and highways.
- Light cast iron pipes are used for house drainage works, whereas, heavy ones are adopted for city sewers.

(6)Steel pipes

- These types of sewers are used where lightness, imperviousness and resistance to high pressure are of paramount importance.
- Their use may be made in outfall or trunk sewers.

Sewer:- Types, design discharge and hydraulic design

(7)Stoneware sewers(vitrified clay sewers)

These sewers are normally favoured for house drainage connections and laterals.

(8)Plastic sewers

Plastic is recent material used for sewer pipes and used for internal drainage works in house.

(9)High Density Polyethylene (HDPE) Pipes

These are commonly used for conveyance of industrial wastewater.

(10)Glass fibre reinforced plastic pipes

This material is widely used where corrosion resistant pipes are required.

(11)Pitch Fibre Pipes-These are generally recommended for uses such as house connection to sewers and septic tanks, farm drainage, down pipes, storm drains, industrial waste drainage, etc. These have recently been manufactured in India.

Sewer:- types, design discharge and hydraulic design

Types of Sewer- Shapes of Sewer Pipes

1. **Circular sewers**
2. **Non-circular shaped sewers**

Sewers are generally **circular** pipes laid below ground level, slopping continuously towards the outfall. These are designed to flow under gravity. Shapes other than circular are also used.

The advantages of circular sewers are:

- The perimeter of circular sewer is the least with respect to the sewer of other shape.
- The inner surface is smooth hence the flow of sewage is uniform and there is no chance of deposition of suspended particles.
- The circular sewers are easy to construct.

Sewer:- types, design discharge and hydraulic design

Non-circular shaped sewers are also adopted for the following reasons:

- They can be construct in such a convenient shape and size so that a man can enter the sewer for cleaning, maintenance, etc.
- The structural strength is more.
- Cost of construction is low.

Sewer:- types, design discharge and hydraulic design

Other Shapes (Non Circular) used for sewers are :

- Standard Egg-shaped sewer
- New egg-shaped sewer
- Horse shoe shaped sewer
- Parabolic shaped sewer
- Semi-elliptical section
- Rectangular shape section
- U-shaped section
- Basket handled shape sewer and
- Semi-circular shaped sewer

Sewer:- types, design discharge and hydraulic design

Standard Egg-shaped sewer

These types of sewers are generally used in combined sewers. These sewers can generate self cleansing velocity during dry weather flow.

Horse shoe shaped sewer

This type of sewer is constructed for carrying heavy discharge. This is like a tunnel and resembles a horse-shoe. The size is so large that the maintenance works within the sewer are very easy.

Parabolic shaped sewer

The upper surface of the sewer is of the shape of a parabola and the invert is in the form of an ellipse. This type of sewer is suitable for carrying small discharges.

Semi Elliptical Shaped Sewer

It may be used for soil i.e. soft soil as it is more stable. It is useful only for carrying large number or amounts of sewage.

Sewer:- types, design discharge and hydraulic design

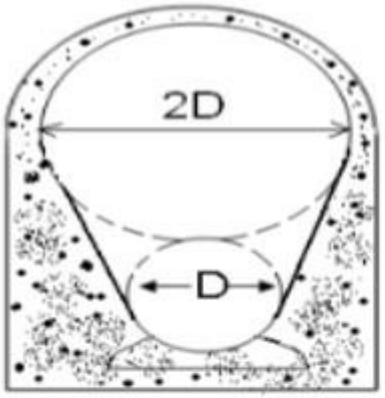
Rectangular shape section -This type of sewer can be easily constructed. These are suitable for large sewers to carry heavy discharge of sewage. The maintenance works are easy in this section.

U-shaped section -The shape of sewer resembles the letter „U". The sewer is suitable for carrying heavy discharges. Maintenance works are very easy in this type of sewers.

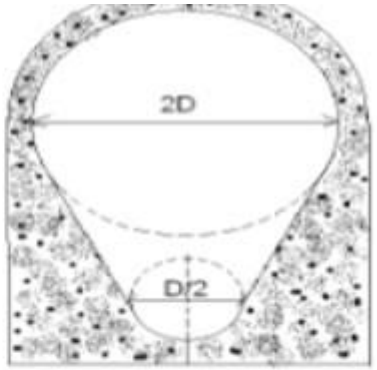
Semi Circular Shaped Sewer-This section gives a wider base at bottom and hence it becomes suitable for constructing large sewers with less available headroom. It is out dated.

Basket handled shape sewer -In this type of sewer, the outer surface is circular. The inner surface is divided into two portions. The upper portion resembles a basket-handle and the lower portion is like a channel. During dry season, the sewage flows through the lower portion and during monsoon, the combined sewage flows through the full section. It is also out dated

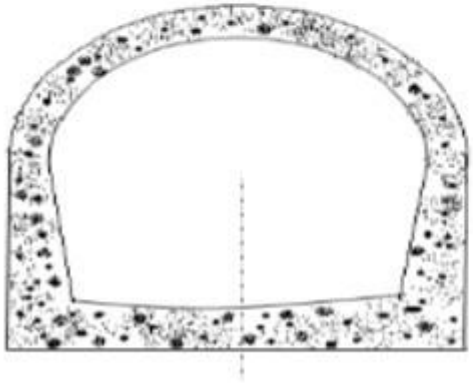
Sewer:- types, design discharge and hydraulic design



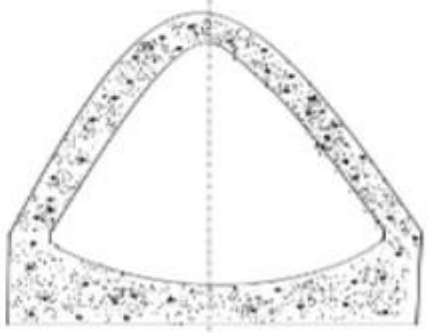
(a) Standard Egg Shaped Sewer



(b) New/ Modified Egg shaped Sewer



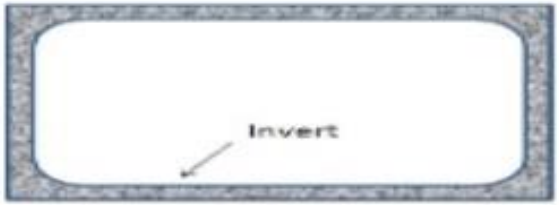
(c) Horse shoe sewer section



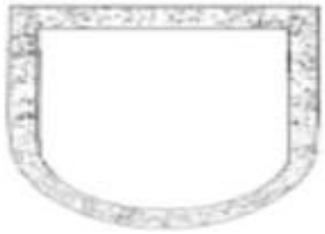
(d) Parabolic section

Sewer:- types, design discharge and hydraulic design

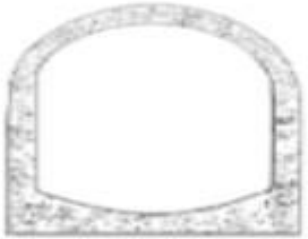
(e) Semi-elliptical section



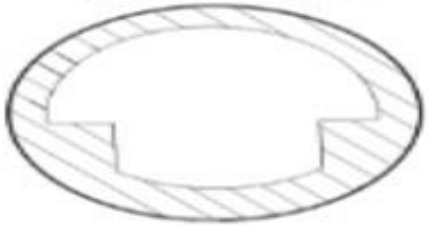
(f) Rectangular Sewer



(g) U-shaped section



(h) Semi-circular Section



(i) Basket-Handle Section

Sewer:- Design discharge

Requirements of Design and Planning of Sewerage System

The sewerage scheme is designed to remove entire sewage effectively and efficiently from the houses to the point of treatment and disposal.

Following aspects should be considered while designing the system.

- The sewers provided should be adequate in size to avoid overflow and possible health hazards.
- For evaluating proper diameter of the sewer, correct estimation of sewage discharge is necessary.
- The flow velocity inside the sewer should neither be so large as to require heavy excavation and high lift pumping, nor should be so small causing deposition of the solid in the sewers.
- The sewers should be laid at least 2 to 3 m deep to carry sewage from basement.
- The sewage in sewer should flow under gravity with 0.5 to 0.8 full at designed discharge, i.e. at the maximum estimated discharge.
- The sewage is conveyed to the point usually located in low-lying area, where the treatment plant is located.

Sewer:- Design discharge

- Sewers need to be designed before commencing the actual laying work.
- Designing involves estimation of **period or duration** for the which the sewer will serve for an expected population and the discharge for which the sewer is to be designed.

Design discharge mainly based on-

- Design Period
- Population Forecasting
- Tributary area
- Per capita sewage flow
- Infiltration
- Sewage from Commercial institutions

Sewer:- Design discharge

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

Sewer:- Design discharge

Design Period

The length of time up to which the capacity of a sewer will be adequate is referred to as the design period.

Following design period can be considered for different components of sewerage scheme.

Laterals less than 15 cm diameter : Full development

Trunk or main sewers : 40 to 50 years

Treatment Units : 15 to 20 years

Pumping plant : 5 to 10 years

Sewer:- Hydraulic design

- The hydraulic design of sewers and drains, means finding out their sections and gradients.
- Domestic and industrial wastewater contains lot of suspended, colloidal and dissolved impurities.
- The velocity of wastewater is non silting non scouring velocity.
- Normally the sewer size of greater than 0.4 m in diameter are designed as running 2/3rd or 3/4th full at max discharge.

Sewer:- Hydraulic design

Waste Water Flow

- When a fluid flows past a point or through a path different parameters associated with the flow of the fluid, certain parameters vary and others may remain constant .
- The two basic parameters of any fluid flow are velocity of the fluid particle or element and the pressure of the fluid at the point under consideration.
- The flow of fluids can be classified in different patterns based on the variation of the flow parameters with time and distance.

Sewer:- Hydraulic design

Classification Based on Variation with Time

1. **Steady Flow**-If the flow parameters, such as velocity, pressure, density and discharge do not vary with time or are independent of time then the flow is steady.
2. **Unsteady Flow-** If the flow parameters vary with time then the flow is categorized as unsteady.

In real conditions it is very rare to have such flows with parameters exactly constant with time. The parameters usually vary with time but variation is within a small range such as the average of particular parameter is constant for certain duration of time

Sewer:- Hydraulic design

Classification Based on Variation with Space

1. **Uniform Flow**-The fluid flow is a uniform flow if the flow parameters remain constant with distance along the flow path.
2. **Non-uniform Flow**-The fluid flow is non-uniform if the flow parameters vary and are different at different points on the flow path.

For a uniform flow, by its definition, the area of the cross section of the flow should remain constant. So a fitting example of the uniform flow is the flow of a liquid thorough a pipeline of constant diameter. And contrary to this the flow through a pipeline of variable diameter would be necessarily non-uniform

A steady flow can be uniform or non-uniform and similarly an unsteady flow can also be uniform or non-uniform. For a steady flow discharge is constant with time and for a uniform flow the area of cross section of the fluid flow is constant through the flow path

Sewer:- Hydraulic design

Hydraulic formulae

1. Chezy's formula

$$v = C\sqrt{Ri},$$

where
V= is the mean velocity [m/s],
C= is the Chézy coefficient [$m^{1/2}/s$],
R= is the hydraulic radius (~ water depth) [m],
i= is the bottom slope[m/m].

- Constant (C) is very complex. Depends on size, shape and smoother roughness of the channel, the mean depth etc.
- C can be calculated by using Bazin's formula.

Sewer:- Hydraulic design

2. Bazin's formula

$$C = \frac{157.6}{[1.81 + (K/R^{1/2})]}$$

Where,

K= Bazin's constant

R= hydraulic radius

Sr. No.	Inside nature of the sewer	K values
1.	Very smooth	0.109
2.	Smooth: bricks & concrete	0.290
3.	Smooth: rubble masonry	0.833
4.	Good, earthen material	1.540
5.	Rough: bricks & concrete	0.500
6.	Rough earthen material	3.170

Sewer:- Hydraulic design

3. Manning's formula

$$V = \frac{k}{n} R_h^{2/3} \cdot S^{1/2}$$

V = velocity of flow (m/s)

k =conversion factor of 1.486 $(ft/m)^{1/3}$

n =Manning coefficient

R_h = hydraulic radius (m)

S = slope of the water surface

* The value of "n" is calculated by kutter's formula

Sewer:- Hydraulic design

4. Kutter's formula

$$C = \frac{k_1 + \frac{k_2}{S} + \frac{k_3}{n}}{1 + \frac{n}{\sqrt{R}} \cdot \left(k_1 + \frac{k_2}{S}\right)}$$

Where

- C = Chézy's roughness coefficient
- S = Friction slope
- R = Hydraulic radius (m,)
- n = Kutter's roughness (unit less)
- k_1 =Constant (23.0 SI,)
- k_2=Constant (0.00155 SI,)
- k_3= Constant (1.0 SI,)

Sewer:- Hydraulic design

5. Hazen – William's formula

$$V = k\,C\,R^{0.63}\,S^{0.54}$$

where:

- V is velocity
- k is a conversion factor for the unit system k = 0.849 for SI units)
- C is a roughness coefficient
- R is the hydraulic radius
- S is the slope of the energy line (head loss per length of pipe)

Sewer:- Hydraulic design

6. Crimp and Burge's formula

$$V = 83.47\, R^{2/3} S^{1/2}$$

Where,

V = velocity of flow (m/s)

R = hydraulic radius (m)

S = slope of the water surface

Sewer:- Hydraulic design

Minimum Velocity

- The flow velocity in the sewers should be such that the suspended materials in sewage do not get silted up; i.e. the velocity should be such as to cause automatic self- cleansing effect.
- The generation of such a minimum self cleansing velocity in the sewer, at least once a day, is important, because if certain deposition takes place and is not removed, it will obstruct free flow, causing further deposition and finally leading to the complete blocking of the sewer.

Sewer:- Hydraulic design

Self clearing velocity

- To calculate minimum velocity of flow following formula is used.

$$V = \sqrt{(8k/f)\ (es - e)/e\ g.ds}$$

where,

V= minimum velocity of flow in m/s.

k= size of solids in sewage varying between 0.06mm

f= Darcy's coefficient of friction (normally 0.03)

Sewer:- Hydraulic design

- e_s= specific gravity of solid material flowing in sewage, varies between 1.2 to 2.65
- e= specific gravity of liquid in sewage (generally 1)
- g= gravitational acceleration cont.
- d_s= dia of solid particles in mm

Sewer:- Hydraulic design

Maximum Velocity

- The smooth interior surface of a sewer pipe gets scoured due to continuous abrasion caused by the suspended solids present in sewage.
- It is, therefore, necessary to limit the maximum velocity in the sewer pipe.
- This limiting or non- scouring velocity will mainly depend upon the material of the sewer.

Sewer:- Hydraulic design

Effects of Flow Variation on Velocity in a Sewer

- Due to variation in discharge, the depth of flow varies, and hence the hydraulic mean depth (r) varies.
- Due to the change in the hydraulic mean depth, the flow velocity gets affected from time to time.
- It is necessary to check the sewer for maintaining a minimum velocity of about 0.45 m/s at the time of minimum flow (assumed to be 1/3rd of average flow).
- The designer should also ensure that a velocity of 0.9 m/s is developed at least at the time of maximum flow and preferably during the average flow periods also.
- Moreover, care should be taken to see that at the time of maximum flow, the velocity generated does not exceed the scouring value.

Thanks