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## CHAPTER-2

### Drinking Water Quality →

- It is determined by the impurities present in it.
- It can be physical, chemical in nature.

#### (i) Physical tests

1 Colour - Coloured water give the appearance of being unfit to drink, even though water may be perfectly safe for public use.  
- Colour can indicate the presence of organic substance such as algae or other compounds.

#### (2) Taste and odour →

- It is the human perception of water quality.
- Human perception of taste includes sourness, saltiness, bitterness and sweetness and produced by organic compounds.

#### (3) Turbidity

- It is the measure of the light transmitting properties of water and composed of suspended and colloidal particles. It is important for health reasons.

#### (4) Solids

- It is the residue remaining after evaporation of water.

#### (ii) Chemical tests

##### (1) Chlorides

- The excess presence of sodium chloride indicates the pollution of water due to sewage mineral etc.

- Water has lower content of salt than sewage due to fact that salt consumed by food is excreted by body.



→ Chloride Content highest 200 mg/litre  
more prominent level 600 mg/litre.

### Dissolved gases →

- Water contains various gases from its contact with the atmosphere and ground surface.
- Hydrogen sulphide gives distinct odour.
- $\text{CO}_2$  content causes corrosion, increases acidity of mineral in water & gives taste.

### Indian Standards for drinking water

<u>Parameter</u>	<u>Permissible</u>
(i) Colour	5 - 25 Hazen
(ii) odour	Agreeable
(iii) Turbidity	5 - 10 NTU
(iv) TDS	300 - 600 mg/l
(v) Aluminium	0.03 mg/l
(vi) Chloride	250 mg/l
(vii) Fluoride	1.00 mg/l
(viii) Free residual chlorine	0.2
(ix) Nitrate	45 mg/l
(x) Sulphate	200 mg/l
(xi) Iron	0.2 mg/l
(xii) Total Hardness	200 mg/l
(xiii) Zinc	5 mg/l

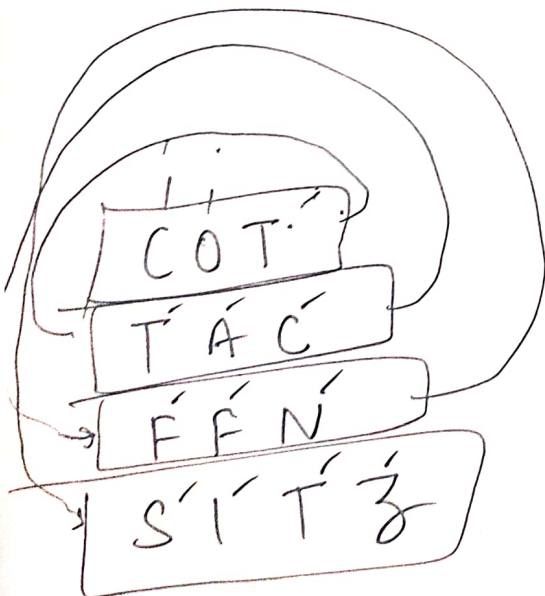


## Parameters concerning toxic substances

<u>Parameter</u>	<u>Permissible (mg/l)</u>
(i) Cadmium	0.002
" Lead	0.01
" Mercury	0.001
(iii) Nickel	0.02
(iv) PCB	0
(v) PAN	0.0005
(vi) Arsenic	0.0001
(vii) Chromium	0.01
	0.05

CLMNPAC

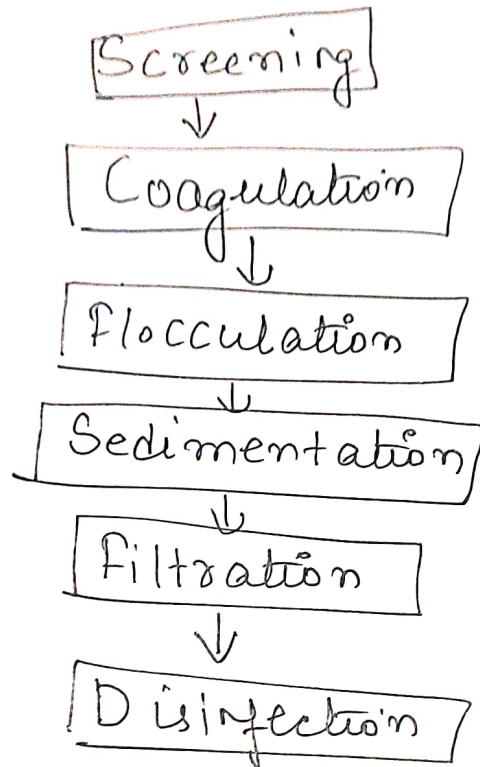
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## Introduction to Water treatment

The raw water must be treated and purified before they supplied to the public for their domestic, industrial and other uses. The steps are.



(i) Screening is used to remove all the floating matter from surface water. It is generally provided at intake points.

(ii) Coagulation During Coagulation, chemical with a positive charge added to water. The positive charge neutralizes the negative charge of dirt and other dissolved particles in the water. When this occurs, the particles bind with the chemicals to form slightly larger particles. Chemicals used are, aluminum sulphate, ferric sulphate etc.



Flocculation follows the Coagulation step. Flocculation is the gentle mixing of water to form large, heavier particles called flocs. Often water treatment plant will add additional chemical during this to form flocs.

Sedimentation is used to separate out solid from the water. During sedimentation flocs settle at bottom of water because of heavier.

Filtration After sedimentation, the clear water is conveyed to filtration tank. In this, clear water is filtered to separate out solid from water. During filtration, the clear water passes through filter that have different pore sizes and made of different material. These filter remove dissolved particles and germs such as dust, chemical bacteria etc. Activated Carbon filter also remove any bad odour.

Disinfection  
After the water has been filtered, water treatment plants may add one or more chemical disinfectants (such as chlorine, Chloramines or chlorine dioxides) to kill the remaining parasites, bacteria or viruses. The remaining disinfectant kills the germs living in the pipes between treatment plants to your tap. After Disinfection it will distribute the water from plant to your tap.



## Importance of Sanitation

- (i) It prevents from pest infestations.
- (ii) It may kill bacteria, germs, viruses etc which are already present.
- (iii) It will reduce the potential for cross contamination.
- (iv) It can help to increase the life of self and other people who lived around you.
- (v) It minimizes the chances of injury.
- (vi) It helps to create a more pleasant environment for work.
- (vii) It prevents us from various health issues like, Diarrhoea, Polio, Hepatitis Typhoid etc.
- (viii) When you practice good sanitation your family saves money on health care and treatment.
- (ix) It improves the quality of life.



## CHAPTER-3 Domestic Waste Water

Quantity  $\Rightarrow$

- (i) Dry weather flow
- (ii) Storm water flow

(i) Dry weather flow  $\Rightarrow$

- a. Domestic or sanitary sewage
- b. Industrial sewage.

Quantity of dry weather flow is determined by considering the following factors.

(i) Infiltration & Exfiltration  $\Rightarrow$

- ↳ leakage of water from ground to sewer
- ↳ leakage of sewage to underground

(ii) Nature of Industries & The quantity of Industrial sewage will depend upon the nature of ~~area~~ industries.

(iii) Population & The quantity of Domestic waste water will also depend on the area of population. When the population  $\uparrow$  the domestic sewage will  $\uparrow$ .

(iv) Rate of Water Supply & The rate of sewage is ~~equal~~ assumed as equal to the rate of water supply.

It depends on two factors &

- (i) Intensity of pressure & If pressure is high, more quantity of water
- (ii) Use of Water &



## Storm Water,

The storm water is to be collected and conveyed in sewer at proper places for the following reason.

- Damp conditions are created which are unhygienic as they provide flourishing grounds for microorganisms.
- Existence of Waterpool after the foundation of structure.
- Initial washing of street by storm water contain organic matter hence such water requires to be collected and to be taken to the treatment plant.
- Low lying areas get flooded and transport system is paralyzed.
- Stagnant Waterpools serve as breeding places for mosquitoes.



## Disposal of Domestic waste water in rural and urban areas →

The methods of sewage disposal can be classified as follows:-

- (i) Disposal by dilution
- (ii) Disposal by land treatment

### (i) Disposal by dilution

In this, the raw sewage or partially treated sewage is thrown into the natural water having large volume. The sewage in due course of time is purified by what is known as ~~Disposal by dilution~~ self purification capacity of water. The limit of discharge and degree of treatment are determined by the capacity of self purification of water.

#### Favourable Condition for dilution

- It is possible only to provide primary treatment to sewage i.e. removal of floating matter and settleable solid.
- Diluting water are not used for the purpose of navigating for atleast some reasonable distance on the downstream from the point of sewage disposal.
- Dissolved oxygen content of diluting water should be high.
- The place is situated near natural water having large volumes.

#### Types of Natural Water

Creeks, Estuaries, lakes, ocean, rivers and streams.



## Self purification of Natural Water

When sewage is discharge into the natural water, its organic matter get oxidized by the dissolved oxygen content in water. The oxidation of organic matter convert such matter into simple inoffensive substance.

Deficiency of Dissolved oxygen thus created in natural water 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 replenishable by atmosphere. This phenomenon which occur in all natural water is known as self purification of Natural water.

### Factor which depend on $\rightarrow$

type of sewage, temperature, velocity of flow, presence of available oxygen. etc.

## Disposal by land treatment

The raw domestic waste water 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 water.

The sewage adds to the fertilizing value of land and crops can be profitable raised on such land. The term sewage farming is also sometimes used for indicating disposal of sewage by land treatment.

### Favourable Condition

- 1 Land should be composed of sandy, loamy or alluvial soil.
- 1 The rainfall in the area is low as it will assist in maintaining good drainage capacity of soil.
- 1 There is demand for cash crops which can be early grown on sewage farms.



→ large open areas in the surrounding locality for practicing broad irrigation by sewage.

Adv

- increases fertility
- It is cheap where land is plenty.
- does not need costly equipment.

Dis

- Sewage farming are not liked by ordinary people
- requires large area for farming

## Introduction to Sewer

Sewers are the underground pipes which carry sewage to the point of discharge or disposal. The sewage originates from building passes through fixtures and then leads to lateral sewer which in turn discharges to submain and main sewer.

House Sewer → This is the sewer system which is most commonly found in domestic houses where the plumbing system in a house is connected to the municipal sewer to carry sanitary sewer.

Lateral Sewer

These sewer carry sanitary sewage from more than one house sewer.

Sub-Main Sewer

Carry from more than one lateral sewer.

Main sewer

Carry sewer from more than one sub-main sewer.

Outfall sewer

Receiving the total discharge from all sewer system and moves it forward for final disposal.



## Different types of sewers acc. to material

### Asbestos (i) Asbestos Cement Sewer (AC)

- AC sewer are manufactured from a mixture of cement and asbestos fibres
- Suitable for carrying domestic sanitary sewage
- Adv - smooth
- light weight

Dis

- Cannot withstand heavy loads
- easily broken

### (ii) Brick sewer

- used for construction large size sewers.
- Very useful for continuation of storm sewer.
- It is replaced by ~~concrete~~ concrete sewer.

### (iii) Cement Concrete

Plain Cement Concrete - dia upto 60 cm

Reinforced Cement Concrete - dia > 60 cm.

### (iv) Cast iron Sewer

It ~~can~~ can withstand high internal pressure and can bear external loads.

### (v) Steel sewer are light, resistant to high pressure, flexible suitable when

- sewage is carried under press.
- This sewage has to cross under a railway track.

### (vi) Plastic sewer

- resistant to corrosion

- lightweight,

- high coeff of thermal expansion.

cannot be used in hot areas



## Shapes of sewer

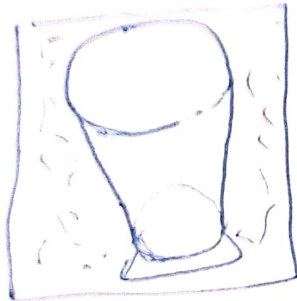
(i) Circular

(ii) Non-Circular

(iii) Non Circular

(i) Egg shaped Sewer

- used in combined sewer
- sewer can generate self cleaning velocity during dry weather flow.

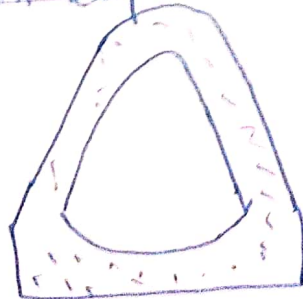


(iii) Parabolic shape Sewer

- upper surface - parabola
- invert is form of ellipse.
- used for carrying small discharge.

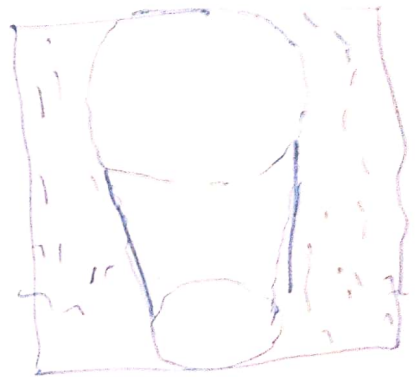
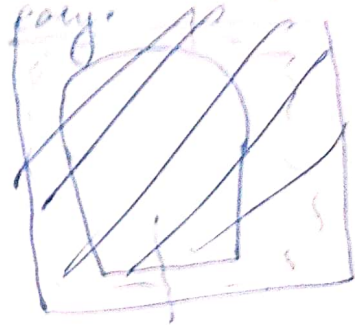


(iv) Semi elliptical



(iii) Horse shoe shaped

- used for carrying heavy discharge.
- size is large so maintenance work is easy.





## Design Discharge for Sewers $\rightarrow$

Designing involves estimation of period or duration for which the sewer will serve for an expected population, and discharge for which the sewer is to be designed.

(i) Design Period  $\rightarrow$  The length of time up to which the capacity of a sewer will be adequate is referred as design period.

(ii) Population forecasting & there are several methods for estimation of population which can be predict population for a specific design period may three to four decades.

(iii) Tributary Area & the natural topography, layout of buildings, political boundaries, economic factors etc determine the tributary area.

For larger drainage system, it is desirable that the sewer capacities be designed for the total tributary area. However, political boundaries and legal restriction prevent the sewer to be constructed beyond the limit of the local authority.

(iv) Pea Capita sewage flow  $\rightarrow$  The Pea factor or the ratio of maximum to average flows depends upon contributory population

Contributory population	Pea factor
Up to 20000	3.00
20001 to 50000	2.50
50001 to 750000	2.25
Above 750001	2.00



## Sewage from Commercial Institution (C).

Industries and Commercial building often use water other than the municipal supply and may discharge their liquid waste into the sanitary sewers. Estimates of such flows to be made separately.

## Hydraulic Design of sewers.

Generally approach for design sewers is similar to the design of water mains.

However there are two differences in the design of sewers and water mains.

(i) Pressure of solid matter, Sewage contains

solid matter (both organic or inorganic) the heavier of which may settle down ~~at~~ at the bottom of sewers as when the flow of velocity reduces, resulting to clogging of the sewer. To avoid the clogging of sewer they must be laid at a such a gradient self cleansing velocity is achieved.

(ii) Pressure of water Water in the water mains flows under pressure. Hence water mains can be carried up and down the gradient. The sewer pipe carry sewage as gravity conduit hence they must be laid at continuous downstream gradient.

## Hydraulic Formulae (



The design of hydraulic sewer is done on the following formulae:

(i) Chezy formula

$$V = C \sqrt{RS}$$

V - Velocity

R - Hydraulic mean

S - Hydraulic gradient

C - Chezy's Constant

$$R = \frac{A}{P} \rightarrow \frac{\text{Area}}{\text{Perimeter}}$$

and  $Q = AV$

(ii) Kutter's formula

$$C = \frac{23 + \frac{0.00155}{S}}{1 + \left[ \frac{23 + \frac{0.00155}{S}}{S} \right] \frac{N}{\sqrt{R}}}$$

$$N = \text{Roughness Coefficient}$$

(iii) Bazin's formula

$$C = \frac{157.6}{1.81 + \frac{K}{\sqrt{R}}}$$

K = Bazin's Constant

(iv) Manning's formula

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$

(v) Crimp's and Bruges's formula

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

$$\frac{1}{n} R^{2/3} S^{1/2} = 83.47 R^{2/3} S^{1/2}$$

$$n = 0.012$$

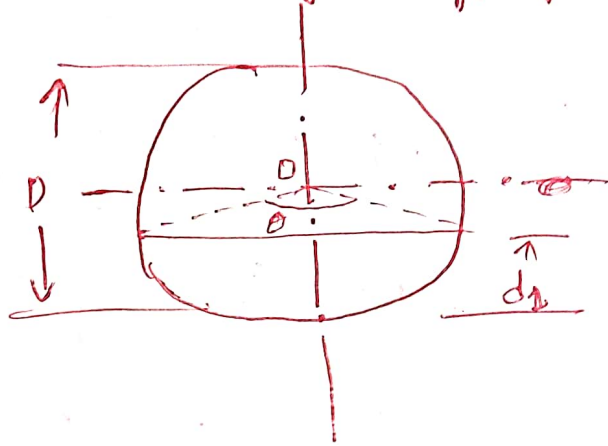


Magen's and William's formula

$$V = 0.85 CR^{0.63} S^{0.54}$$

hydraulic element of sewer

- Commonly used sewer is circular
- Hydraulic element for diff flow condition



(a) Circular sewer running full

Area of cross section  $A = \frac{\pi}{4} D^2$

Wetted perimeter  
Hydraulic mean  
depth.

$$P = \pi D$$

$$R = \frac{A}{P} = \frac{D}{4}$$

Velocity

$$V = \frac{1}{N} R^{2/3} S^{1/2}$$

$$Q = A \cdot V = \frac{A}{N} R^{2/3} S^{1/2}$$

Discharge

$$= \frac{0.3116}{N} D^{8/3} S^{1/2}$$



## Circular sewer running partially full

Central Angle  $\theta$  is given by  $\cos \frac{\theta}{2} = \left(1 - \frac{2d}{D}\right)$

$$(i) \text{ Depth } d = \frac{D}{2} - \frac{D}{2} \cos \frac{\theta}{2} = \frac{D}{2} \left(1 - \cos \frac{\theta}{2}\right)$$

$$\text{proportional depth} = \frac{d}{D} = \frac{1}{2} \left(1 - \cos \frac{\theta}{2}\right)$$

$$(ii) \text{ Area } a = \frac{\pi}{24} D^2 \times \frac{\theta}{360} - \frac{D}{2} \cos \frac{\theta}{2} \frac{D}{2} \sin \frac{\theta}{2} \\ = \frac{\pi}{4} D^2 \left[ \frac{\theta}{360} - \frac{\sin \theta}{2\pi} \right]$$

$$\text{Proportion of area} = \frac{a}{A} = \frac{\theta}{360} - \frac{\sin \theta}{2\pi}$$

(3) Wetted perimeter

$$P = \frac{\pi D}{360} \theta$$

$$\text{proportional perimeter} = \frac{P}{\pi D} = \frac{\theta}{360}$$

$$(4) \text{ Hydraulic mean depth } r = \frac{a}{P} = \frac{\frac{\pi}{4} D^2 \left[ \frac{\theta}{360} - \frac{\sin \theta}{2\pi} \right]}{\frac{\pi D}{360} \theta} \\ = \frac{D}{4} \left[ 1 - \frac{360 \sin \theta}{2\pi \theta} \right]$$

$$\text{Hydraulic mean } r = \frac{r}{R} = \left[ 1 - \frac{360 \sin \theta}{2\pi \theta} \right]$$

$$(5) \text{ Velocity of flow } V = \frac{1}{N} R^{2/3} s^{1/2}$$

$$\text{proportional velocity } \frac{V}{V} = \frac{N}{n} \left( \frac{r}{R} \right)^{2/3}$$



$$\frac{v}{V} = \left( \frac{r}{R} \right)^{2/3} = \left[ 1 - \frac{360 \sin \theta}{2\pi \theta} \right]^{2/3}$$

Discharge  $\frac{Q}{360} \left[ 1 - \frac{360 \sin \theta}{2\pi \theta} \right]^{5/3}$

### Minimum Velocity

For prevention of settlement of solids we have to maintain the minimum Velocity.

$$V_s = \sqrt{\frac{8P}{f} (G_s - 1) G_{ds}}$$

### Maximum Velocity

If it is too high, it will reduce the life of sewer.



# Introduction to domestic Waste Water treatment

- (i) Screening (removal of floating matter)
- (ii) Grit removal

it is used to remove the grit, sand and such other inorganic matter from sewage.

- (iii) Primary Sedimentation

known as settling tank.

→ the process of sedimentation reduce the strength of sewage to the extent about 30 to 35%.

- there is reduction in B.O.D to the extent of about 30 to 35%.

- Quality of settleable solid in solid is reduced to the extent of about 80 to 90%.

- (iv) Sedimentation

When velocity of flow is decreased, the sewage is at rest and suspended particles rest at bottom known as sludge.



4) Aerobic biological suspended growth process /  
its function is to convert the  
colloidal, dissolved and residual organic  
matter into settleable biofloc and  
stable inorganic, they can be achieved  
by activated sludge process.

5) Aerobic biological attached growth process  
— similar to previous one.  
— it can be achieved by trickling  
filters or rotating biological contactor

(VI) Anaerobic biological growth process /  
— it is used to convert organic matter  
into methane and carbon dioxide  
and relatively stable organic residues  
Anoxic filter, fluid bed etc are some of  
the methods adopted for this  
process.