LECTURE NOTES

ON

WATER SUPPLY & WASTE WATER ENGINEERING

DIPLOMA 5TH SEMESTER

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01. INTRODUCTION TO WATER SUPPLY AND QUANTITY AND QUANTITY OF WATER

NOTES

Introduction.

Water is used for many purposes associated with human activities. In it's natural state it occurs in and on the ground in sub-surface and surface reservoirs.

The characteristics of water i.e, chemical physical, and biological while differ greatly depending upon the location and (type of source).

Water Supply System.

This process consists of supply of purified water to the consumers by appropriate treatment of water by considering it's source.

Need or Requirement of water supply.

The sanitation of area is considerably done by improving the supply of water.

Sources of Water.

1. Surface Sources

The surface source is the source in which water is available on the group surface

i.e :- River, Pond and Lake

• River
It is the main source of water supply system. The river water contains silt particles and suspended impurities. So, the river water requires proper treatment process.

• Pond.
A pond is a man-made water body.

The pond water contains full of impurities so, the pond cannot be adopted as water supply system.

• Lake
A large area of water surrounded by land and not connected to the sea expect by river and streams.

→ Storage Reservoirs
An artificial storage of water by construction of dam across a valley or river is called Reservoirs.

2. Underground Sources

It is the type of source in which the water which percolates to the ground is broad into the surface

→ Different Underground sources.

• Infiltration Gallery

It is a horizontal drain made from open jointed or perforated pipe or a block drain, which is laid below the water table and collects ground water.

These are constructed in water bearing strata by various porous drain pipes. A collecting well at the down stream and of the gallery services as the some from where infiltrated supply is pumped out.

• Infiltration Wells.
These are the structures that

allow surface runoff to drain through unground pipening.

- Spring.

When the ground water appear on the surface due to any reason it is called Spring.

The main 03 types of springs are:-

I. Artesian
II. Gravity
III. Surface

- Well.

A well is defined as an artificial hole or pit meet in the ground for the purpose of tapping the water.

These are of 04 types :-

I. Shallow well.
II. Deep well
III. Artesian Well
IV. Tube Well.

1. Shallow Well.

It is constructed as the upper most layer of the earth diameter of the

shallow is 6 m. It may be lined or unlined.

II. Deep Well

It obtains the water from the aquifer below the impervious layer

III. Artesian Well.

It allows the water by the principal of hydraulic conductivity.

The quantity of water is very pure. It doesn't require any water treatment process for purification.

IV. Tube Well.

It is a one type of deep well having diameter 50mm to 200mm. It obstacted obtains from aquifer the depth is about 30-50 m.

This discharge of the tube well doesn't exceed 40-50 litre per second. It may contains hardness.

Quantity of Water

It is necessary while designing of water supply scheme for a town (or) city.

The first duty of the engineer is to determine the water demand of the town and then find out the water sources from where demand can be fulfill.

This calculation is based on two factors :-

1. Rate of Demand.

11. Population.

1. Rate of Demand.

The requirement of water for various purposes is calculated and the rate of Conservation per capita head is calculated.

11. Population

The population to which water is to be supplied is calculated and estimated for future.

→ Types of Demand.

1. Domestic Water Demand.

2. Commercial and Industrial Demand.

3. Fire demand

4. Demand for Public

5. Compensation Losses Demand.

1. Domestic Water Demand.

It includes the quantity of water required in the houses for drinking, bathing, Cooking, washing, etc.

The quantity of water required for domestic use mainly depends upon the habit, social status, Climatic conditions and customs of people.

In India on average domestic consumption of water under thermal condition of water is 135 lit/Capita/day as per IS-1172-1171

In development countries this figure may be as higher as 350 lit/Capita/day

Uses	Consumption (lit/cap./day)
(1) Drinking	5
(2) Cooking	5
(3) Bathing	55
(4) Washing clothes	20
(5) Washing utensils	10
(6) Washing and cleaning of houses and residence	10
(7) Flushing	30
	135 lit/cap/day

2. Commercial and Industrial Demand:

Commercial building and commercial centres including, office, warehouses, store, hotels, shopping malls, health centers, schools, temples, cinema houses, railway station and Bus station, etc.

The water requirement in commercial places may be upto 45 lit/cap./day

3. Fire Demand.

The quantity of water required for fire fighting is generally calculated by using the following formulae :-

i) National Board of Fire.

Under Writter's Formula :-

$$\boxed{Q = 4640\sqrt{P}(1 - 0.01\sqrt{P})}$$

where,

Q = Quantity of water required in lit/min.

P = Population of town in thousand.

ii) Freeman Formula.

$$\boxed{Q = 1135.5\left(\frac{P}{10} + 10\right)}$$

Both the formulae give higher water demand.

∴ Not suitable for Indian condition.

iii) For Indian conditions Kuchling's formula give statisfactory result.

$$\boxed{Q = 3182\sqrt{P}}$$

iv) Buston's Formula.

$$\boxed{Q = 5663\sqrt{P}}$$

Fire generally breaks out in thickly populated locality and industrial area which causes serious damage of property and sometimes loss of life.

Fire may take place due to faulty electric wire by sort circuiting fire catching material, explosions, bad intention of criminal people or any other unforeseen mess happening.

If fires are not properly controlled on time, it may lead to serious damage & may burn the cities.

4. Demand for Public

Quantity of water required for public utility purposes such as for washing and sprinkling of roads, cleaning of

sewage, watering of public park, garden public fountain, etc comes under public demand.

To meet the water demand for public use provision of 05 % of the total consumption is made while designing the water works for a city.

Table : 1 → Water Requirement for Public Purpose.

	Purpose	Water Requirement.
i.	Public parks	1.4 litres/m^2/day
ii.	Street Washing	1.0 - 1.4 litres/m^2/day.
iii.	Sewer Cleaning	4.5 litres/head/day.

Table : 2 → Water Requirement for Live Stock.

	Live Stock	Water Requirement in litres/animal/day.
i.	Cows	68.25
ii.	Hogs	18.20
iii.	Chickens	0.09.

iv.	Goats	13.60
v.	Horses	45.50
vi.	Sheep	13.60.

Table No : 3.

	Purposes	Water Requirements
i.	Public parks	16850 litres/hectare/day
ii.	Private gardens	16850 litres/hectare/day.
iii.	Roadside trees	28150 litres/km/day.

4. Compensation Losses Demand.

Losses include wastage due to defective pipe joints, cracked and broken pipes, faulty values & fittings, sometimes consumers keep their taps open, unauthorized and illegal connections.

Generally, allowance of 15% of the total quantity of water is made to compensate for losses, thefts and wastage of water.

Per Capita Demand.

For the purpose of estimation of total requirement of water, the demand is calculated on an average basic which i[s] expressed in liters/capita/day

$$\text{Per Capita Demand} = \frac{Q}{P \times 365} \text{ lit./cap./day}$$

→ For an average Indian town, the requir-ments of water in various uses is [as] under :-

i.	Domestic use	135 litres/capita/day
ii.	Industrial	40 litres/capita/day
iii.	Public use	25 litres/capita/day
iv.	Business or trade	15 litres/capita/day
v.	Losses, wastage and thefts.	55 litres/capita/day
	Total	= 270 litres/capita/day

Design Period

The number of years for which the design of water works has to be done is called design period.

This period should neither be short nor to long. Mostly design period is 20-30 years

Forecasting Population.

After fixing the design period the next step is to determine the populations in various periods.

The following are the standard methods for forecasting population :-

1. Arithmetical Increase Method.
2. Geometrical Increase Method.
3. Incremental Increase Method.
4. Decreasing Rate Method.
5. Simple Graphical Method.
6. Comparative Graphical Method.
7. Master Plan Method.
8. Logistic Curve Method.
9. Apportionment Method.

1. Arithmetical Increase Method.

This method is based on the

assumption that the population is increasing at a constant rate. The rate of change of population with time is constant.

Change (Increase) in population per decade is constant.

$$P_y = P + nC$$

No of population in nth year

No of population in previous year

No. of decade

Constant change in population

Forecast of population for three years in population by Arithmatical Increase Method.

Year	Population	Increase in Population.
1940	8,000	12000 − 8000 = 4000
1950	12,000	17000 − 12000 = 5000
1960	17,000	22500 − 17000 = 5500.
1970	22500	
1980	?	
1990	?	
2000	?	

Average increase in popopulation per decade $= \frac{4000 + 5000 + 5500}{3}$

$= 4833.3$

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$\therefore C = 4833.3 = 4800$

$P_{1980} = P_{1970} + n.c$

$n = 1980 - 1970 = 10$ years
$= 1$ decades

$= 22500 + 1 \times 4800$
$= 27300$

$P_{1990} = P_{1970} + n.c$ $\left[\begin{array}{l} n = 1990 - 1970 \\ = 2 \text{ decades} \end{array} \right]$

$= 22500 + 2 \times 4800$
$= 32100$

$P_{2000} = P_{1970} + n.c$ $\left[\begin{array}{l} n = 2000 - 1970 \\ = 3 \text{ decades} \end{array} \right]$

$= 22500 + 3 \times 4800$
$= 36900$

2. Geometrical Increase Method.

This method is based on the assumption that the percentage increase in population from decades to decade remains constant.

In this method the average percentage of growth of last few decades is determine. The population forecasting

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is done on the basis that percentage increase per decade will be the same.

If the present population is 'P' and the average growth is 'I_i' the population at the end of 'n' decade will be :-

$$P_n = P\left(1 + \frac{I_i}{100}\right)^n$$

Forecasting of population by geometrical increase method :-

Year	Population	Increase in Population	in population %age increase
1940	8000	4000	50%
1950	12000	5000	41.6%
1960	17000	5500	32.35%
1970	22500		

Avg. increase in population % $= \frac{50 + 41.6 + 32.35}{3}$

$= 41.31\%$

$\therefore I_i = 41.31$

$P_{1980} = P_{1970}\left(1 + \frac{I_i}{100}\right)^n$

$n = 1980 - 1970 = 10$ years
$= 1$ decades.

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$$P_{1980} = 22500\left(1+\frac{41.31}{100}\right)^1$$
$= 31794.75$
$= 31800.$

$$P_{1990} = 22500\left(1+\frac{41.31}{100}\right)^2$$ [n = 1990 - 1970 = 2 decades
$= 44929.16$
$= 44900$

$$P_{2000} = 22500\left(1+\frac{41.31}{100}\right)^3$$ [n = 2000 - 1970 = 3 decades]
$= 63489.40$
$= 63500.$

3. Incremental Increase Method.

This method is improvement over the above two methods.

The average increase in population is determine by the arithmetical method and to this is added the average of the net implemental increase once for each future decades.

Year	Population	Increase in Population	Incremental Increase in pop.
1940	8000	4000	1000
1950	12000	5000	500
1960	17000	5500	
1970	22500		

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$$I_a\,Avg. = \frac{4000 + 5000 + 5500}{3}$$
$= 4833.33$
$= 4833.$

$$I_c\,Avg = \frac{1000 + 500}{2}$$
$= 750.$

$$\boxed{P_n = P + n(I_a + I_c)}$$

$P_{1980} = P_{1970} + n(I_a + I_c)$

n = 1980 - 1970
= 10 years
= 1 decades

$= 22500 + 1(4833 + 750)$
$= 28083.$

$P_{1990} = P_{1970} + 2(4833 + 750)$ { n = 1990 - 1970 = 2 decades
$= 22500 + 2(4833 + 750)$
$= 33666.$

$P_{2000} = P_{1970} + 3(4833 + 750)$ { n = 2000 - 1970 = 3 decades
$= 22500 + 3(4833 + 750)$
$= 39249.$

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4. Decreasing Rate Method.

It has been seen that all life growth within limited space. If the complete growth of a very old city is platted it will be seen that the curve has S- shape, which indicates that early growth rate takes place at an increasing rate, later growth at a decreasing rate which indicates that saturated limit has reached.

In this method average decrease in the percentage increase is workout and is then subtracted from the latest percent-age for each successive decades.

Year	Popula-tion	Increase in Population	% age increase in population	Decrease in percentage
1940	8000	4000	50%	8.4%
1950	12000	5000	41.6%	9.2%
1960	17000	5500	32.4%	
1970	22500			
			Avg. = 41.31%	Avg. decrease in the % age

% age increase for 1980 = 32.4 - 8.8
= 23.6%

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$P_{1980} = 22500 + 2200 \times \frac{23.6}{100}$

$= 2780.$

% age ↑ (increase in population) 1990 =
= 23.6% - 8.8%
= 19.8%

$P_{1990} = 27810 + 27810 \times \frac{19.8}{100}$

$= 27810\left(1 + \frac{19.8}{100}\right)$

$= 31925$

Quality of Water.

- Whole some Water.

Water which is not chemically pure but does not contain anything harmful to human body.

- Impurities in Water.

1. Suspended Impurities
2. Colloidal Impurities
3. Dissolved Impurities.

1. Suspended Impurities.

i. Silt clay
ii. Algae, fungi
iii. Organic & Inorganic matter
iv. Turbidity

2. Colloidal Impurities.

i. Neither in suspension nor in solution.
ii. They are electrically charged.
iii. Micron.

3. Dissolved Impurities.

i. Salts of Calcium, magnesium and sodium.
ii. PPm (Parts Per million)

→ Physical Test

i. Colour
ii. Taste and odour
iii. Temperature.

→ Chemical Test

i. Total Solids
ii. Hardness
iii. Chlorides

iv. Dissolved Gases
v. PH- Value or Hydrogen - Ion Concentration
vi. Nitrogen and its compounds.
vii. Metals and other chemical substances.

→ Bacterialogical Test.

i. M.P.N Test
ii. E.Coli Test

PHYSICAL TEST.

1. Turbidity :- It is caused due to presence of suspended and colloidal matter in the water.

The character and amount of turbidity depends upon the type of soil over which the water has moved.

The groundwater is less turbid than the surface water.

→ Turbidity → It is a measure of resistance of water to the passage of light through it.

Turbidity is expressed as NTU (Nephelo-metric Turbidity Units) or PPm (Parts Per Million).

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Turbidity can be determined using any of these —

i. Turbidity rod.
ii. Jackson's Turbidity Meter (JTU Turbidity Unit)
iii. Bali's Turbidi Meter.

2. Colour and Temperature.

Colour —
Colour in water is usually due to organic matter in colloidal solution but sometimes it is also due to mineral and dissolved organic impurities.

The colour produced by 1 miligram of platinum in 1 litre of water has been fixed as the unit of colour.

The permissible colour for domestic water is 20 ppm on platinum cobalt scale.

Temperature —
Temperature of water is measured by ordinary thermometers.

The most desirable temperature for public supply is between 44°c to 10°c for public supply because it is not potable.

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3. Taste And Odour.

These are in water may be due to presence of dead or alive microorganism dissolved gases such as hydrogen sulphide, methane, carbon dioxide or oxygen combined with organic matter, mineral substances such as sodium chloride, Iron - compounds and carbonate and sulphates of other substances. Water having bad odour is objectionable.

CHEMICAL TEST

PH-Value of Water —

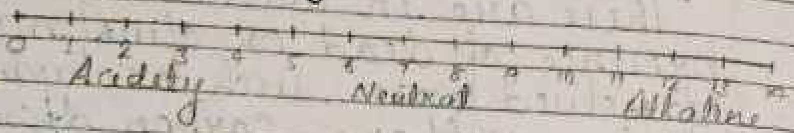
PH-Value denoted the concentration of hydrogen ions in the water and it is a major of acidity or alkalinity of a substance.

Depending upon the nature of dissolved salts and minerals. The PH-Value ranges from 0-14.

For pure water PH-value is 7 and 0 to 7 is acidic, 7-14 is alkaline in nature.

For public water supply PH-value may

may be 6.5 – 8.5. It is determine by PH papers or by PH-meter.



Hardness of Water —

It is property of water which prevents the lathering of soap.

Hardness is of two types —
I. Temporary Hardness
II. Permanent Hardness

1) Temporary Hardness :- It is cause due to the presence of carbonates and sulphide of Calcium and Magnesium. It is removed by boiling.

II.) Permanent Hardness :- It is cause due to the presence of Chlorides & Nitrates, Calcium and Magnese.

It is removed by Zeolite.

Hardness is usually in mg/l or ppm of Calcium carbonates

Drinking water standard = 200 mg/l
Or 200 ppm of $CaCO_3$.

Chlorides Content.

The natural water near the mines and sea dissolved sodium chloride and also the presence of other chlorides may be due to the mixing of saline water.

Excess of chlorides is dangerous and unfit for use.

The chloride can be reduced by diluting the water.

Chlorides above 250 ppm are not permissible in water. ($\ngtr$ 250 PPm).

BACTEREOLOGICAL TEST.

The examination of water for the presence of bacteria is important for the water supply engineer from the view point of public health.

The bacteria may be harmless to the man kind. This category is non-pathogenic bacteria.

Many of the bacteria found in water are derived from air, soil and vegetation.

Some of these are able to multiply and continue their existance while the remaining die in the dew course of time.

The selective medium that promotes the growth of particular bacteria and inhibits the growth of other microorganisms is used in the lab to detect the presence of required bacteria. Usually Coliform bacteria.

→ The solution having particles larger than atom and molecules but not visible to naked eyes.

Treatment of Water

Raw Water → Plain sedimentation → Coagulation → Filtration

Plain sedimentation ↓ suspended particles

Coagulation ↓ Colloidal particles

Filtration ↓ Dissolved Organic substances

Filtration → Disinfection → Whole some water to distribution

Disinfection ↓ Pathogens

Ground Water Treatment

Ground Water → Aeration → Softening → Filtration

Aeration ↓ Undesirable dissolved gas CO_2 H_2S

Softening ↓ Hardness

Filtration ↓ Dissolved Organic Substances

Filtration → Disinfection → Whole some with for distribution

Disinfection ↓ Pathogens

→ Plain Sedimentation.

I. Plain sedimentation is the first unit operation employed to capture suspended particles in water.

II. Suspended particles in water remain in suspended suspention due to turbulance and flow velocity.

III. All the particles whose specific gravity is more than that of water has tendency to settle down. But the turbulents and flow velocity of a resistance.

IV. Plain sedimentation is the process or

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method of moving the suspended particles present in water by controlling turbulence and flow velocity & their by giving rise to particle settlement by virtue by on mass.

Water Borne Disease.

World Health Organization has observed that 80% of communicable disease that are transmitted through water

The disease like Cholera, Gastroenteritis typhoid, amebiasis, diarrhea, Polio, Hepatitis (Jaundice), Leptospirosis, Dracunculiasis are caused by bacteria.

Screening.

Screens are fixed in the intake work entrance of the treatment plant.

Objects like wood, leaves, aquatic plants, plastic and etc, are removed from water in this process

→ Types of Screening.

i. Rotatory Screening Method.
ii. Bar Screening Method.

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→ Principle of Plain Sedimentation.

i. It follows type one setting.

ii. It deals with discrete particles settlement in dilute suspension.

iii. Discrete particle is the 1 which don't alter it's size, shape, specific gravity with respect to time and space.

→ Sedimentation Added with Coagulation

When water contains fine clay and colloidal impurities which are electrically charged are continuously in motion and never settled down due to gravitational force.

Certain chemical are added to the water so as to remove such impurities which are removed by playing sedimentation.

The chemical formed insoluble, gelatinous flocculent precipitates absorb and entangle very fine suspended matter and colloidal impurities during its formation and descent through water.

These coagulants also have an advantage of removing colour, odour, taste from

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the water. Turbidity of water get reduced upto 5 to 10 ppm and bacteria is removed upto 65 %.

Sl. No.	Coagulant	PH Range	Dosage mg/l
1.	Aluminium Sulphate $Al_2(SO_4)_3 \cdot 18H_2O$	5.5 - 8.0	5 - 85
2.	Sodium Aluminate $Na_2Al_2O_4$	5.5 - 8.0	3.4 - 34
3.	Ferric Chloride ($FeCl_3$)	5.5 - 11.0	8.5 - 51
4.	Ferric Sulphate $Fe_2(SO_4)_3$	5.5 - 11.0	8.5 - 51
5.	Ferric Sulphate $FeSO_4 \cdot 7H_2O$	5.5 - 11.0	8.5 - 51

Filtration

The process of passing the water through beds of sand or other granular material is known as Filtration.

Commonly used media are :-

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a) Silica sand
b) Anthracite Coal
c) Granite (green sand).

In India use silica sand.

→ Filters
The place were media is packed and water is passed through media is known as Filters.

- Classification of Filters.

i.) Based on the force :-

a. Gravity Filter
b. Pressure Filters.

ii.) Based on rate of filtration:-

Volume of water filtered in unit time in unit surface.

a. Slow filters area
b. Rapid filters

iii.) Based on Media :-

a. Single Media.
b. Dual Media.
c. Multi-media or mixed media

- Slow Sand Filter

It is a single sand filter, single media gravity type.

Rate of filtration (ROF) = 100 to 200 l/hr/m²
particles removing efficiency = 98% to 99%

Coagulated water is not allowed to pass through slow sand filter.

If it is allow to pass smaller particle in Coagulated water grows inside in the filter media and blocks the media permanent and causes operational problems.

- Components of slow sand filter

i. Filter Box :- Rectangular, open to atmosphere, water type tank, Size - 100 to 2000 m^2, slope 1 in 100.

ii. Filter Media :- Silica sand is used as thickness - 90 cm to 110 cm.

→ Effective size of sand (D_{10}) -

0.2 to 0.35.

Uniformatic Coefficient (Cu) = $\frac{D_{60}}{D_{10}}$ = 1.5 to 3

Smaller the particles → Smaller pore size → More contact area → Slow Rate of filtration → Better quality of water.

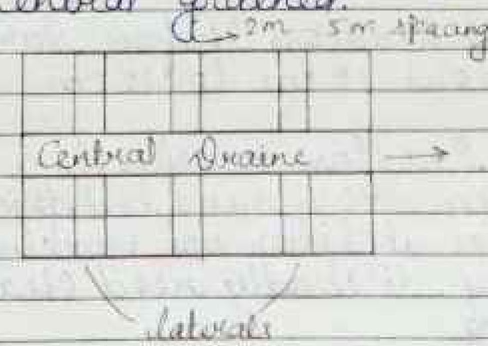
iii. Gravel Bed

Gives support to sand medium thickness 30 cm to 45 cm.

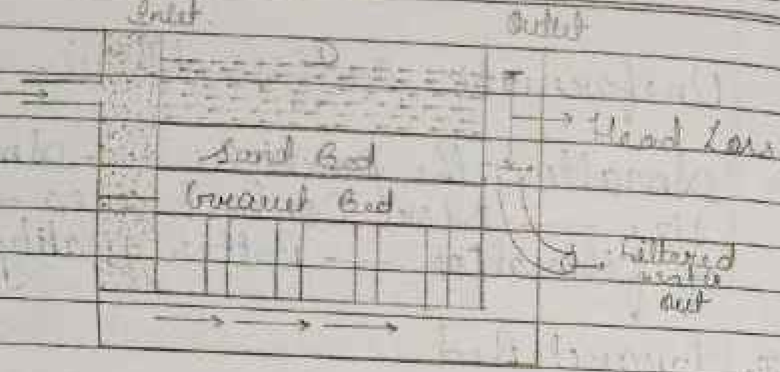
Size - 3mm to 6 mm (well greated gravel) it doesn't permit sand particles to escape from filter medium.

iv. Under Drainage System.

It is an open drainage system laterals and Central drained.



v. Inlet And Outlet.



Inlet
To apply water uniformly over the sand bed.

Outlet
To collect filtered water at constant weight.

Piezometer
To know the water level of the sand bed.

Initial headloss (Before starting the filtration) 10 cm to 15 cm.

When headloss reaches to a value of 70 cm to 90 cm (90% sand bed thickness) it indicates at filter not working at rated capacity. It badly need cleaning or washing.

Slow sand filters are cleaned once in every 1 month to 3 month.

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Top 1.5 to 3 cm of sand bed is scrapped off until the depth of bed gets reduced to 50 cm. Behind this coarse bed is found (low filtration) so the scrapped off fine sand is washed with 0.2 to 0.6% of filter water.

Drinking Water Standards.

→ Physical –

Temperature	10°C to 20°C
Colour	5 to 20 TCU TCU = mg/l = ppm
Turbidity	5 to 10 units
Odour & Taste	TON < 3 Threshold odour number

→ Chemical –

Total Solids	TS ≤ 500 mg/l
PH	6.5 to 8.5
Alkalinity	≤ 200 mg/l as $CaCO_3$
Hardness	< 300 g/l as $CaCO_3$

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Chlorides	$\leq$ 250mg/l
Sulphates	$\leq$ 250 mg/lt
Dissolved Oxygen (Do)	3 to 4 mg/l
Flourides	1 < Flourides $\leq$ 1.5 mg/l
Ammonia Nitrogen	$\leq$ 0.15 mg/l
Organic Nitrogen	$\leq$ 0.3 mg/l
Nitrites	0 (NIL)
Nitrates	$\leq$ 45 (mg/l)
Iron	< 0.3 mg/l
Maganese	< 0.5 mg/l.

→ Toxic - Chemical substances.

Lead	< 0.1 mg/l
Arsenic	< 0.05 mg/l
Barium	< 1 mg/l
Baron	< 0.01 mg/l

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Cadmium	< 0.01 mg/l
Chromium	< 0.05 mg/l
Mercury	< 0.001 mg/l
Phenols	< 0.001 mg/l
Cyanide	< 0.05 mg/l

MEASUREMENT —

1. Temperature — Thermometer
2. Colour — TINTOMETER measured on Burgess scale or platinum scale.

Expressed :- (TCU) True Colour Units

1 TCU = 1 mg of platinum as a Chloro-platinatic ion mixed in 1 l of distilled water, Colour produced is taken as 1 TCU

3. Turbidity

Measured on silica scale and expressed in terms of.

Turbidi Units (T.U).

1 standard T.U — 1 mg of finely

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   Turbidi Units (T.U).
   1 standard T.U — 1 mg of finely

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divided silica mixed with 1 l of distilled water, turbidity produced is taken as 1 standard T.U.

JTU - Jackson Turbidi Unit.

Device working on the principle of light absorption -

Jackson Turbidi Rod — for field measurement

Jackson Turbidi Meter — >25 JTU.

Baylis Turbidometer — 0 to 5 JTU.

Hillegemeter — 10 to 50 JTU.

Rapid Sand Filter

1. Initial head loss — 10mm to 15mm.
2. Filters are operated till it reaches the following criteria :-

Terminal head loss reaches = 3m
Turbidity — 2.5 NTU.

It reaches any of these conditions in 24 hrs or 48 hrs.

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3. Frequency of cleaning of RSF = 24 hrs to 48 hrs
4. Process of Cleaning :- (Back washing).
5. Percentage of water used for cleaning = 2% to 6%.
6. Filter Box.

→ Open, watertight, rectangular tank.
size = 10 to 80 m^2.
Bed slope - 1 in 100.

7. Filter Media.

Thickness — 60 to 90 cm
Effective size of sand — D_{10} = 0.35 to 0.55 mm
Uniformity Coeff. — C_u = 1.2 to 1.8.

Gravel Bed —
Thickness — 60 cm to 90 cm
size — 3 mm to 40 mm.

8. Closed Drainage system.

• Pressure Filters.

These are rapid sand filters where filtration is under pressure

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These are used in swimming pools, hospital, industries, private Builings etc.

Rate of filtration is equal to :-
= 6000 to 15000 l/hr/m²

Particle removal efficiency = η = 60% to 70%

Pressure with which filtration is carried out = Pressure need :- 30 m to 70 m.

D_{10} = 0.5 to 0.7 m
C_u = 1.2

It is nothing but rapid sand filter placed within a closed water tight steel Cylinders

The water passes through the sand bed under a pressure greater than atmospheric pressure.

All the operation of this filters is similar to rapid gravity filters, except that the coagulated water is directly applied to the filter without mixing and flocculation.

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Mostly pressure filters are used for industrial plant because these are much suited for such places. These are not economical on large scale.

Advantages of Pressure Filter

I. It is a compact unit and now a days automatic pressure filter units have been design requiring no manual operation

II. These filters are very flexible because the rate of filtration can be change by the change of compressed air pressure over water.

III. No sedimentation and coagulation tanks are required with these filters.

Disadvantages of Pressure Filter

I. Over all capacity of the filter is small though the rate of filtration is per square meter is high

II. It is Uneconomical

III. As the process of filtration and back washing is done in the closed tank

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proper quality control and inspection is not possible.

IV. This inspection, cleaning, chang of filter media, gravel and repair of under drainage system is difficult.

V. Due to circular shape in plan the design and fixing of back water channel is difficult.

VI. Their efficiency is removal of bacteria and turbidity is poor.

VII. They require additional pump to water to into them.

Disinfection of Water

The process of killing the infective bacteria from the water and making it safe to the user is called Disinfection.

→ Requirement of Good Disinfection.

I. They should destroy all the harmful pathogenic organisms from the water.

II. They should not take more time but do

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their task within the require time at normal temperature.

III. They should be economical and easily available.

IV. After their treatment the water should not become toxic and objectional to the user.

V. They should be off such a nature that their strength or concentration in the treated water can be easily determined.

→ Methods of Disinfection

a. By Heat energy (e.g → Boiling of water)
b. By Light energy (e.g → U.V rays)

a) Disinfection by Boiling

I. Water can be disinfected by the boiling of 15 to 20 minutes.

II. When temperature is greater than >80°C → 100% Removal of bacteria.

III. It has no residual power.

IV. Advice during epidemis.

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b) Disinfection by U.V Rays.

I. Ultraviolet rays are invisible light rays having wave length of 1000 to 4000 m.

II. It is high destructive power

III. It penetrates into cell by damaging the proto-plasm.

IV. This process is very costly and require technical skill therefore it is not usually used.

V. It has no residual power.

Chemical Treatment.

I. Excess lime Treatment.

II. Treatment with Metal Iron

III. Treatment with Potassium Permagnent.

IV. Treatment with Ozone (Ozanisation)

V. Treatment with Iodine and Bromine

VI. Treatment with Chlorine.

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VII. Treatment with silver.

Chlorination.

This process is very economical.

It has high residual power and protect water for long period.

It takes reasonable time.

$\boxed{Cl_2 + H_2O \xrightarrow[\text{Hydrolysis}]{} HOCl + Cl^-}$

$\boxed{HOCl \rightleftharpoons H^+ + OCl^-}$ Ionisation

HOCl :- Hypochlorous Acid.
OCl⁻ :- Hypochlorite

When chlorine or (Cl_2) is added to water it first hydrolyses and then ionises.

HOCl and OCl^- together known as free Chlorine or freely available chlorine.

Freechlorine produced diffuse into cells of micro-organisms and form chloro toxic substances which precipitate

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enzymes and nutrients and destroy micro-organisms.

HOcl is micro more powerful than OCl⁻. But HOcl and OCl⁻ have equal destroying capacity once they entered the cell wall.

Important: Formation of HOcl and OCl depends on PH.

$PH < 7.5 \longrightarrow HOCl > OCl^-$
$PH > 7.5 \longrightarrow OCl^- > HOCl$

Factors Affecting Bacterial Efficiency of Chlorine.

1. Time of Contact.

The death rate goes on decreasing with time therefore the no. of organisms destroyed per unit of time is proportional to the no. of organisms remaining.

2. The concentration of disinfectants.

The time required to effect the contact percentage of bacteria or other

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micro-organisms by any disinfectants depends upon

3. The number of organisms.

So, the higher no. of organisms the greater percentage of destruction

4. Temperature of Water.

The rate of reaction with enzyme increases with temperature. Therefore, the death rate increases with increase in temperature.

5. PH of Water

The change of PH-value also has a great effect on the disinfecting power of Chlorine. A smaller contact period is required when the PH-value is low.

6. Presence of Various Chemicals.

Various chemical present in water will react with Chlorine which is added for disinfection and thus, reduce the concentration of Chlorine available for direct disinfection.

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PH – 0 to 5.5 → Only HOCl formed in water

PH – 5.5 to 7.5 → Both HOCl and OCl⁻ is formed but HOCl >>> OCl⁻

PH – 7.5 to 10.5 → Both HOCl and OCl⁻ formed OCl⁻ >> HOCl.

PH > 10 → Only OCl⁻ is formed.

- Chlorine Demand

Chlorine demand is defined as the difference between the amount of Chlorine added to the water and the amount of chlorine remaining at the end of a specified contact period.

→ The chlorine demand for a sample of water depends on :-

1. Nature and concentration of chlorine consuming substances present in water.

II. Time to contact

III. PH - value of Water.

IV. Temperature of Water.

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V. Variable conditions in the process of Chlorination.

VI. And there are so many other factors

→ Break Point Chlorination.

When chlorine is added to water it reacts with organic and inorganic matter and forms common compounds. some portion of Chlorine remains as residual Chlorine, which is not the true.

It is very weak in disinfection. Now if the chlorine dose is increased the combined available residual chlorine will also increase.

When the chlorine dose is increased the compounds get oxidised and no residual is found.

If the addition of chlorine is continued and graph is plotted between chlorine dose and residual chlorine we obtain this curve.

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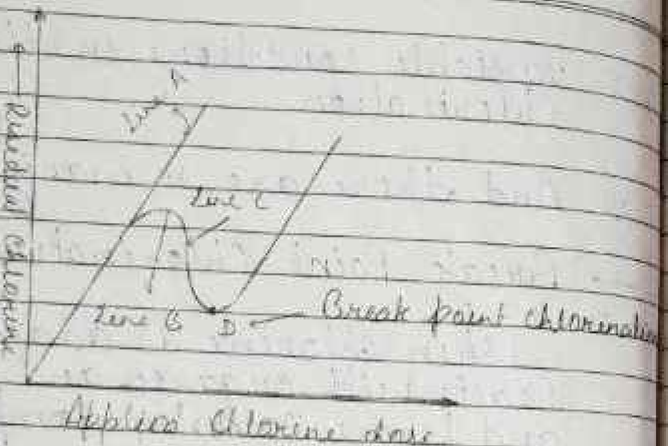

On studying the curve it will be noticed that the residual in the begining increases with the applied chlorine dose but after point C it suddenly drops upto point D.

Portion OC shows formation of Chloramines and portion CD shows their Oxidisation.

Point D at which residual chlorine again starts increasing is known as Break point chlorination.

After reaching this point if chlorine is added is remains as free residual chlorine and the curve becomes a straight line.

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→ Water free from chlorine demand.

Cl_2 dose = Cl_2 demand - Cl_2 residual

Cl_2 demand = Cl_2 dose - Cl_2 residual

Cl_2 demand = 0
Cl_2 dose = Cl_2 residual.

- Different Type of Chlorination

1. Plain Chlorination :- Where good surface water is available it is used with no other treatment except chlorination
   e.g :- Springs

2. Pre-Chlorination :- When chlorine is added to raw water before any treatment it is known as Pre-Chlorinate

3. Post-Chlorination :- When chlorine added in the water after all the treatments it is known as Post Chlorinat

4. Double Chlorination :- When chlorine added to raw water at more than one point it is recommended when water is highly contaminated.

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5. Super Chlorination.

It is defined as the administration of a dose considerably in excess of that necessary for the adequate bacterial purification of water.

More than normal dose epidemis.
(> Normal dose epidemis)

6. Dechlorination

It is defined as removable of excess chlorine.

Softening of Water

The removal or reduction of hardness from the water is known as Water Softening.

The main advantage of water softening is reduction in the consumption of soap.

→ Removal of Temporary Hardness -

a. By Boiling.
b. By addition of lime to water.

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a) By Boiling
When the water is boiled having temporary hardness the following reactions takes place

$Mg(HCO_3)_2 \xrightarrow{Boiling} MgCO_3 \downarrow + CO_2 \uparrow + H_2O$

$Ca(HCO_3)_2 \xrightarrow{Boiling} CaCO_3 \downarrow + CO_2 \uparrow + H_2O$

The calcium and magnesium carbonates are insoluble in water and the removed in sedimentation tanks.

This is a very costly process so it is not possible to use it in the water works. However, it can be adopted as individual basis.

b) Addition of Lime Water.

$Mg(HCO_3)_2 + Ca(OH)_2 \longrightarrow Ca(HCO_3)_2 \downarrow + Mg(OH)_2$

The calcium carbonate and magnesium hydroxide are insoluble in water and get precipitated and can be removed by sedimentation tanks.

This method is used in softening water which contains only temporary hardness.

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If the water contains temporary as well as permanent hardness permanent softening methods are used.

→ Removal of Permanent Hardness.

Removal of permanent hardness from water is difficult and requires special methods and equipment for it's removal.

Following are the various methods which are commonly adopted for the removal of permanent hardness from the water.

1. Lime Soda Process.
2. Base Exchange Process.
3. Demineralisation Process.

1. Lime Soda Process.

If water contains sulphate of calcium and magnesium, simply addition of lime cannot remove the hardness but if soda-ash is added in lime, the non-carboneceous hardness can be easily removed. So, the process is known as Lime Soda Process.

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- The following chemical reactions take place while removing hardness by this method :-

I. $Mg(HCO_3)_2 + Ca(OH)_2 \longrightarrow Ca(HCO_3)_2 \downarrow + Mg(OH)_2 \downarrow$

II. $Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow CaCO_3 + 2H_2O$

III. $Mg(CO_3) + Ca(OH)_2 \longrightarrow Mg(OH)_2 \downarrow + CaCO_3 \downarrow$

IV. $MgSO_4 + Ca(OH)_2 \longrightarrow Mg(OH)_2 + CuSO_4$

V. $CaSO_4 + Na_2CO_3 \longrightarrow CaCO_3 \downarrow + Na_2SO_4$

VI. $MgCl_2 + Ca(OH)_2 \longrightarrow Mg(OH)_2 \downarrow + CaCl_2$

VII. $CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 \downarrow + 2NaCl$.

- From the above reactions the following points are noted.

i) Limes reacts with bicarbonates of calcium and magnesium to form carbonates and water

ii) Calcium carbonate is insoluble and settles in the form of precipitate.

iii) Magnesium carbonate react with additional lime and are converted into magnesium

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hydroxide which is insoluble in water and settles in water.

iv) Magnesium calcium sulphates and chlorides reacts with soda-ash and lime and form insoluble precipitates and is clear from above reactions.

→ Advantages of Lime Soda Process

i. It is very economical.

ii. If this process is combined with sedi-mentation with coagulants lesser amount of coagulants shall be required.

iii. The PH-value of the water is increased after this process which will reduce the corrosion of the distribution pipe.

iv. The total mineral contents of the water also reduced in addition to hardness removal of water.

v. Upto certain extend the iron and maganese are also removed from the water.

vi. Sometimes the increased value of alkalinity kills the pathogenic bacteria and

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reduced the load of disinfection plant.

→ Disadvantages of Lime Soda Process.

i. The operation requires careful operation and skilled supervision for removing the hardness efficiently and economically.

ii. If proper recarbonation is not done incrustation pipe walls will be done and will cause trouble in the operation of the filters

iii. Large quantity of insoluble precipitate in form of sludge is obtained.

iv. This process can remove hardness of upto 50 mg per litres which is good for drinking water from health point of view but it increases laundry expenses

9. Base Exchange Process.

This process is also known as Zeolite process or cation exchange process.

The process depends on the ability of certain insoluble substances (Mainly silicates) to exchange cation with the other substances dissolve in water.

The hard water is passed through a bed of zeolite sand (complex silicates of aluminium and sodium), while passing through it the calcium and magnesium cation get replaced by sodium from the exchanger and water becomes soft.

The sodium from the zeolite goes on getting exhausted and after sometime it cannot remove the hardness of water. But the reactions are reversible and the zeolite can be recharged by passing through it in a solution of common salt.

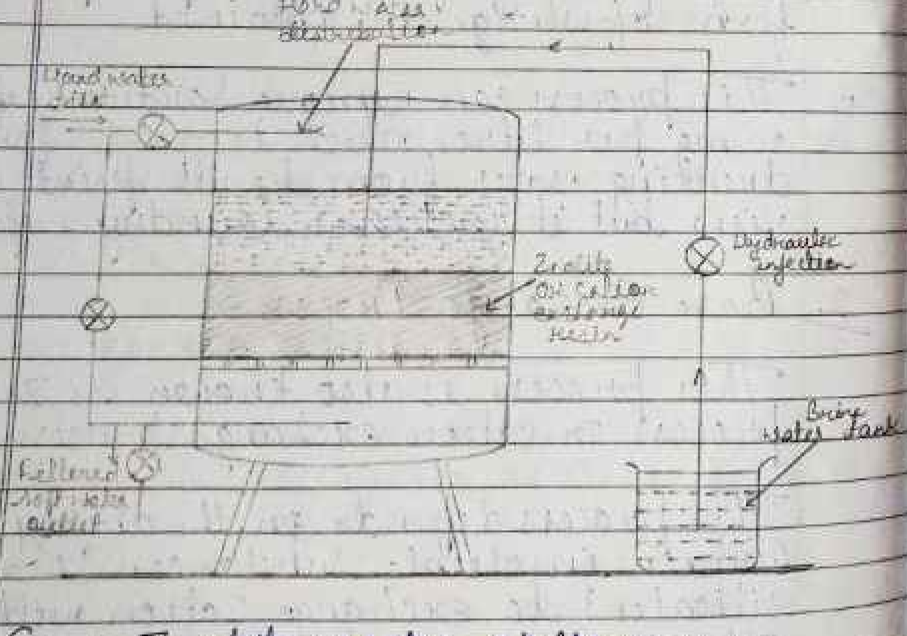

Fig: Zeolite water softener

The zeolite softener resembles a pressure filter. In this unit zeolite is provided in place of filter media.

The hardwater is allowed to enter from the top and is evenly distributed over the bed of zeolite. After passing through the zeolite the treated water is collected at the bottom.

When sufficient quantity of water has been treated and the calcium and magnesium has replaced the sodium in zeolite.

It is regenerated by passing a solution of 10% common salt through it (Braine solution.

The excess brain solution retained by the zeolite after the treatment is removed by washing it with good water.

The zeolites usually treatwater at the rate of 300 litres/per min/meter square.

The zeolite softener usually remove the whole hardness from the water but as fully soft water is not required in public supply it is the common practice to

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remove the hardness from a portion of the water and mixed it with the remaining water.

Distribution System

For efficient distribution, it is required that water should reach to every consumer with required rate of flow. Therefore, some pressure in pipeline is neccesary which should force the water to reach at every place.

Depending upon the method of distribution system is classified as follows :-

i) Gravity System
ii) Pumping system
iii) Dual System.

i) Gravity System

When some ground sufficiently high above the city area this can be best utilized for the distribution system in maintaining pressure in water pipes.

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The water flows in the mains due to gravitational force. As low pumping is required.

Therefore, it is more realiable system for the distribution of water. In this case pumping is not required at any stage.

The design of the distribution system of pipes are done in such a way that water head at the consumers door is just minimum required and the remaining head is fully consumed in frictional and other losses

ii) Pumping System

In this system water is directly pumped in the mains. Since the pumps have to workout different rates in a day. The maintanance cost increases.

iii) Dual System

This is also known as combined system gravity and pumping system.

The pump is connected to the mains as well as to an elevated reservoirs.

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in the begining when demand is small the water is stored in the elevated reservoirs.

But when demand increases the rate of pumping the flow in the distribution system comes from both the pumping station as well as elevated reservoirs.

As in this system water comes from two sources one from reservoirs and second from pumping station, it is called system.

This system is more realiable and economy.

This system is usually adopted every-where.

→ Advantages from Dual System

1. The balance reserve in the storage reservoirs will be utilized during fire. In case, the fire demand is more the distribution and the supplier of few locality is closed.

II. This system is economical efficient and realiable.

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III. This system has the advantages that during the power failure the balance water stored in the reservoir will be supplied to the town.

The pumps have to work at a constant speed, without any variation in their speed. This increases the efficiency of the pump and reduced the wear and tear of the pumps. The super-vision, operation and maintenance of these pump is less as compare to the pumps working at variable speed.

Layout of Distribution System

Depending upon their layout and direction of supply they are classified as follows:-

I. Dead-end or tree system.

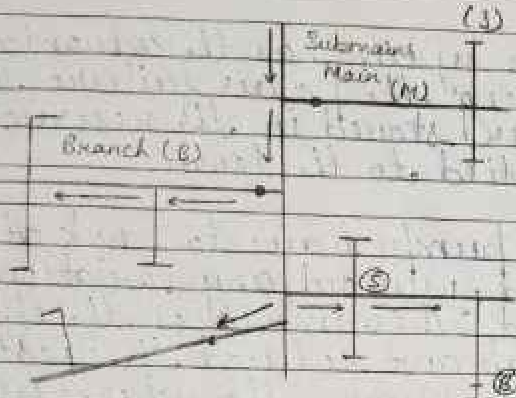
II. Grid Iron system or Recticulation System Or Interlaced system

III. Circular or Ring system

IV. Radial system

I. Dead-end or Tree system.

A supply main starting from the



service resirvoir is laid along the main road. The sub-mains are connected to the mains in both direction along the other roads.

Sub-mains divide into several branch lines. Service connections are taken from these branches to the individual houses.

→ Suitability of Dead end system.

For old towns and cities with irregular and unplanned development.

→ Advantages

I. Quite simple design.

II. Less number of Cult off values.

III. Easier expansion

IV. Short pipe lines lengths required.

V. Cheap and ~~ecomical~~ economical.

Disadvantages.

Considerable area gets affected during repairs.

I. - Water stagnation at dead ends lead to pollution

II. - Water rate of supply cannot be encreased in case of fire breakouts.

III. - Less successful in maintaining satisfactory pressure in the remote part.

II Grid Iron System.

Mains, sub-mains and branches are interconnected with each other.

Main line runs through centre of the area.

→ Suitability - Well planned cities

→ Advantages

I. Since water reaches from different

Periphery (Boundary)

direction size of pipe get reduced.

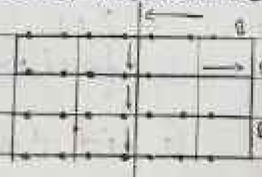
ii. Very small area gets affected in case of repairs

iii. Due to free circulation water cannot be polluted.

iv. More water can be diverted in case of fire breakout.

→ Disadvantages

i. More number of pipes and values are required.



ii. It is costlier.

iii. It's design it difficult.

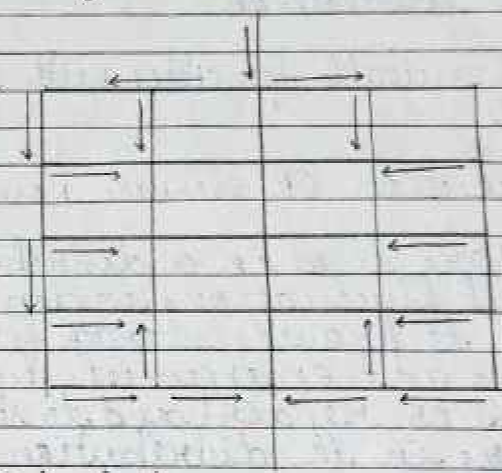
III Ring System OR Circular System.

Main pipe is laid peripherally :-

Laying of mains peripherally increase the pressure of at fartherest.

Suitable for towns and cities having well planned roads.

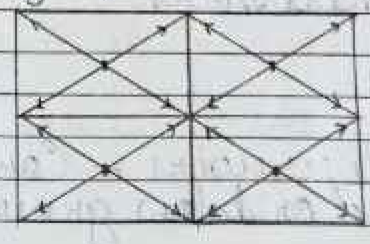
Advantages same as Grid System



IV Radial System

The area is divided into small distribution zones and in the centre of each zone a distribution reservoir is provided.

Water from these reservoirs is supplied through rapidly laid distribution pipe running towards the periphery the periphery of the zone.



It ensures high pressure and efficient water distribution.

It is suitable for cities with radial roads.

Distribution OR Service Reservoirs.

These are used in a distribution system to meet fluctuations in demand of water, to provide storage for the fire fighting and emergencies such as break downs or repairs and to stabilised pressure in the distribution system.

→ Types of Service Reservoirs.

According to the situation with respect to ground the distribution reservoirs are classified in the following three types.

1. Surface Reservoirs
2. Elevated Reservoirs
3. Standpipes

1. Surface Reservoirs — Constructed at ground level or below ground level.

Surface reservoirs should be placed at high points in the distribution system.

2. Elevated Reservoirs. — Constructed at an elevation from ground level. It may be called as Overhead tanks.

3. Standpipes — They boost the pressure. A standpipe is a vertical cylindrical tank resting just above the ground.

Appurtenances in distribution system.

1. Valves
2. Manholes
3. Fire hydrants
4. Water meters

1. Valves :- Valves are provided in the pipe lines to control the flow of water, to isolate and drained section for test, inspections, cleaning and repairs to regulate pressures and to release or admit air.

→ Types of Valves.

1. Sluice Valve Or Gate Valve.
   Used to regulate the flow of water through the pipelines.

ii. Butterfly Values — Used to regulate and stop the flow specially in large size conduits.

iii. Globe Value. — To regulate flow. These values are normally used in pipes of smaller diameter less than 100mm and as water taps.

iv. Check Value — Also known as reflux value or non-returned values. A check values allow water to flow in one direction only and the flow in the reverse direction is automatically stopped by it.

The reflux value is placed in a pumping main. So that if the pump fails or stops water is prevented from flowing back to the pump and thus, pumping equipment is saved from possible damage.

v. Air Value OR Air Relief Values.
The air value helps to admit air into the pipe when the pipe is being ~~is to~~ emptied or when negative or vaccum pressure is created in the pipe.

Air values operates automatically while allowing air to escape from or to entre a pipe.

vi. Scour Value — OR Blow off or Drain Values — Provided for completely emptied emptying or draining of the pipe for removing sand or silt deposited in the pipe.
There are located at dead ends, depressions or low points in the pipeline.

vii. Pressure Relief Values. — Also called as overflow towers and are provided to keep the pressure in a pipeline below a predetermined value and thus, protect it against bursting due to excessive pressure.

Thus, these values are often placed at low points where the pressure is high. Further a pressure relief value is usually provided on the upstream side of the sluice value. So that the pipeline lying on the upstream side of the value is relief of water hammer pressure.

2. Manholes

Manholes are provided at suitable intervals, along the pipeline for inspection and repairs.

Usually they are placed at 300 m to 600 m apart on large pipelines. They are most useful position are at summits And downstream of main valve.

3. Fire Hydrants.

Hydrants is an outlet provided in a pipeline for tapping water mainly for the purpose of fire fighting. Also, are used for withdrawing water for certain other purposes such as sprinkling on roads; flushing streets, etc.

Generally fire hydrants are placed at important road junctions and at interval not exceeding about 300m.

4. Water Meters

Installed in pipelines to measures the quantity of water flowing through them

There are two types of water Meter.

I. Inferentical type meter OR Velocity meter - (Used for large pipe.

II. Displacement type meter - (These are used for small pipes and domestic connections.)

Location of Leaks.

For locating leaks in water supply pipe following methods may be used.

a. By direct observations.
b. By using sounding rods.
c. By plotting hydraulic grade line
d. By using waste detecting meters (Deacon's Meters)

Sounding Rods -

A metal rod is inserted into the ground at the suspected portion, if there is a leak in the pipe the sound of the water escaping through the leak can be heard by placing the ears against the rod or by means of an amplifying device such as aqua-phone or sonoscope.

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02. SOURCES AND CONVEYANCE OF WATER

NOTES.

Sources of water:-

1. Surface Sources
2. Ground Sources

1. Surface Sources
   Streams, lakes, ponds, rivers, impounded reservoirs, stored rain water etc.

2. Ground Sources
   Springs, infiltration galleries, wells, porous pipe galleries, etc.

Streams

In mountaneous region, streams are formed by runoff. Those stream which dry up in summer and contained water only during rainfall are known as "Raining Streams".

Lakes

Water from springs and streams generally flows towards their basins and lakes are formed.

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The quantity of water in the lake depends on its basin capacity, catchment area, annual rainfall, porosity of the ground

Rivers

Rivers are born in the hills. When the discharge of large no of springs and streams combined together.

Rivers are the only surface sources of water which have maximum quantity of water which can be easily taken.

Ponds

These are depression in plains like lakes in mountains in which water is collected during rainy season.

Impounded Reservoirs.

The discharge in some river remains sufficient to meet the hot weather demand, but in some rivers the flow becomes very small and cannot meet the requirements of weather.

Therefore, we construct impounded reservoirs.

The construction of impounded reservoirs is not feasible under the following conditions

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a. Average annual rainfall is lower than average demand, in this case no extra water is available to meet the hot weather demand.

b. When the rate of flow in the streams in dry season is more than the demand

Stored Rain Water.

At some places where neither ground water nor surface water is easily available the only way to store the rainwater in tanks of roof or buildings.

The rainwater from roof is collected in water tight tank with the help of Channel and supplied for utilization.

Ground Water

i. Infiltration

The entrance of rainwater or melted snow into the ground is known as Ground Infiltration.

ii. Percolation

The movement of water after entrance is known as percolation

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Portion of water percolates in the ground and its stored as ground water at hard strem

→ Ground Water Flow.

The water table of under ground generally corresponds to water level of strem river and sea depending on their position

The elevation of ground water table floats with the rainfall, temperature pressure, rate of pumping form wells and other natural condition

Partically it has been seen that all the groundwater is in motion

→ Ground Water Yield.

When the water enter in the ground it starts filling in pores when all the voids of pores are filled with water, the soil is known as saturated soil.

When the ground water soaked by the soil is drained or taken out by gravity drainage. It is found that the quantity of water obtained is less than the volume of voids inside the soil.

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As some quantity of water is retained by the soil particles due to than molecular attraction and it is not possible to drain out the whole quantity of water nearly by gravitational force. The water so retained in the soil particles is known as Pellicular Water.

→ Specific Yield

The ratio of the volume of water obtained by gravity drainage to the total Volume of the sub-soil.

$$\text{Specific Yield} = \frac{\text{Volume of Water Obtained by gravity drainage}}{\text{Total Volume of sub-soil}} \times 100$$

→ Specific Retention

It is the ratio of quantity of water retained by the soil against gravity drainage to the volume of of sub-soil.

$$\text{Specific Retention} = \frac{\text{Volume of water held against gravity drainage}}{\text{Total Volume of sub-soil}} \times 100$$

→ Porosity = Specific yield + Specific retention

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Springs.

Sometimes groundwater reappears at the ground surface in the form of springs.

Springs generally can supply small quantity of water. Hence, these cannot be used as a source of water for big town

→ Formation of Springs –

When the surface of the earth drops sharply the water bearing stratum is exposed to the atmosphere and springs are formed.

Infiltration Galleries.

We have seen earlier that groundwater travels towards lake, rivers, streams. This water which is travelling can be intercepted by digging a trench or by constructing a tunnel with holes on sides at right angle to the direction of flow of underground water.

These underground tunnel used for tapping underground water near rivers lakes or streams are called 'Infiltration Galleries'.

The yield from these galleries may be as much as ~~@~~ 1.5×10^4 litre per day / per meter length

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of infiltration gallery.

Sometimes these are also known as Hori-zontal walls.

Infiltration Wells

These are shallow wells constructed under the beds or nalas and rivers.

These wells are very suitable for Indian conditions where there are deposites of sand porous material at least 3 m deep in river beds.

In the sandy beds of a rivers much quantity of water percolates down. As the water passes through sand which act as filter it's all suspended organic and inorganic impurities are removed.

Therefore the quality of such water is better than river water.

Infiltration wells and infiltration galleries are based on same principles.

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05. W/S PUMPING IN BUILDING

NOTES

Pump And Pumping Station

→ Circumstances under which pumping is required :-

The function of the pump is to lift water or any fluid at higher elevation or higher pressure.

In water works pumps are required under the following circumstances.

I. At the source of water to lift the raw water from rivers, streams, wells, etc and pump it to the treatment work.

II. At the treatment plant to lift the water at various units so that it may flow in them due to it's gravitational force only during the treatment of water.

III. For the backwashing and of filters and increasing their efficiency.

IV. For pumping the chemical solution at treatment plant.

V. For filling the elevated distribution reser-

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voirs or overhead tank.

vi. To increase the pressure in pipe lines by boosting up the pressure.

vii. For pumping the treated water directly into the water mains for it's distribution.

When the water is drawn from surface source situated at higher level than the treatment plans the water will flow under the gravitational force only to the water works. If the surface source is at lower elevation the water will have to be pump to the water works.

Classification of Pumps.

a. Classification based on their principles of operation.

I) Desplacement Pumps.

II.) Centrifugal Pumps.

III.) Airlift Pumps.

IV.) Impulse Pumps.

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b. Classification based on the type of power required.

I.) Electrically driven pumps.

II.) Gasoline Engine Pumps.

III.) Steam Engine Pumps.

IV.) Diesel Engine

c. Classification based on the type of service.

I) Low Lift Pumps

II) High Lift Pumps.

III.) Deep-Well Pumps.

IV.) Booster Pumps.

V.) Stand By Pumps.

• Displacement Pumps —

In these type of pumps vaccum is created mechanically by the moveable parts of the pump.

In the vaccum first water is with-drawn inside the pump which on the return of the mechanical part of the pump is displaced and forced out of the chamber through the values & pump.

The back flow of the water is prevented by means of suitable values.

→ The fallowing are the main two types of Displacement.

i. Reciprocating Pump.
ii. Rotary Pump.

II • Roto-Dynamic Pumps.

A Roto-Dynamic Pump has a wheel or a rotating element that rotates the water inside a case. The rotating element is called as impeller and it helps in imparting energy to the water means.

The shape of the impeller should be such that it forces the water outward in the direction at right angle to it's ~~excess~~ axis or give the water both an axial as well as radial velocity or force the water in axial direction alone.

→ Based on the type of force imparted Roto-Dynamic Pumps can be further classified as :-

i. Centrifugal Pumps
ii. Axial flow Pumps.

i. Centrifugal Pumps :- A centrifugal p[ump] is a mechanical design to make a fluid by means of rotates transfer rotation energy from one or more driven rotors called Impellers.

Centrifugal pumps are used to transport fluids by the conversion of rotational kinetic energy to hydro-dynamic energy of the fluid flow.

The rotational energy typically comes from an engine and electric motor.

Centrifugal pumps are commonly used to transfer water, chemical and light fuel because they are well suited for transporting large volumes of low viscosity liquids.

→ Priming And Operation of Centrifugal Pump.

Before starting the centrifugal pump usually they require priming.

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Before starting the centrifugal pump usually they require priming.

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Priming is the process of removing the tracked air from the pump and filling it completely with water.

The centrifugal pumps which are installed below the water level do not require priming.

ii) Axial Flow - Machines & Pumps

Axial flow pumps have a motor driven rotor that directs flow along a path parallel to the axis of the pump.

The fluid then travels in a relatively straight direction from the inlet pipe through the pump to the outlet pipe.

1. Reciprocating Pump.

Reciprocating Pump is a positive displacement pump where certain volume of liquid is collected in an enclosed volume and is discharged using pressure to the required application.

Reciprocating Pumps are more suitable for volumes of flow at high pressure.

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Advantages of Centrifugal Pump

I. Due to compact design, they require very small space

II. They can be fixed to high speed driving mechanism

III. They have rotary motion due to which there is no noise

IV. They are cheap in cost

V. They have simple mechanisms due to which they can be easily repaired.

VI. They have very simple operation

VII. They cannot be damaged due to high pressure.

Disadvantages of Centrifugal Pump.

I. The rate of flow of water cannot be regulated

II. They cannot be operated without prime movers.

into the cylinder.

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iii. Their speed cannot always be adjusted to the prime mover without speed regulating mechanism.

iv. For operation they have restricted suction.

v. Any air leakage on suction side will affect the efficiency of the pump.

vi. They have high efficiency only for low head and discharge.

vii. The pump will run backward, if it is stopped with the discharge valve open

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→ Components of Reciprocating Pump:

i. Suction Pipe
ii. Suction Valve
iii. Delivery Pipe
iv. Delivery Valve
v. Cylinder
vi. Piston and Piston rod
vii. Crank and Connecting rod
viii. Strains
ix. Air Vessel

→ The working Reciprocating Pump is as follows:-

1. When the power source is connected to Crank, the crank will start rotating and Connecting rod will also get displaced along with crank.

2. The piston connected to the connecting rod will move in linear direction. If the crank moves outwards then the piston moves towards its right and create vacuum in the cylinder.

3. This vacuum causes suction valve to open and liquid from the source is forceably sucked by the suction pipe into the cylinder.

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4. When the cranks moves inward and towards the cylinder the piston will move towards its left and compress the liquid in the cylinder.

5. Now the pressure makes the delivery valve to open and liquid will discharge through delivery pipe.

6. When the piston reaches its extreme left position whole liquid present in the cylinder is delivered through delivery pipe.

7. Then again the crank rotates outwards and piston move to right and to create suction and the whole process is repeated

- Generally the above process can be observed in a single acting reciprocating pump where their is only one delivery stroke per one revolution of crank.

- But when it comes to double acting reciprocating pump there will be two delivery strokes per one revolution of crank.

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Uses of Reciprocating Pump.

i. Oil drilling operations

ii. Pneumatic pressure system

iii. Light Oil pumping

iv. Feeding small boilers and Condensate return

2. Air Lift Pumps

When the water contains suspended matters and acids or alkalies which may damage other types of pump, the air lift pumps can be used very successfully.

These types of pump are suitable for lifting water from small wells and deep wells.

Working of an Air Lift Pump.

The compressed air released through the air diffuser connected at the lower end of the air inlet pipe. This air is mixed with water and forms bubbles having low specific gravity.

When compressed air is passed the density of water inside the pipe is reduced due to which the mixture of water rises in the pipe.

3. Impulse Pump

The impulse pump is a quite energy efficient, multi-function pump.

Impulse pump use pressure created by gas (usually air).

In some impulse pump the gas trapped in the liquid is released and accumulated somewhere in the pump creating a pressure that can push the liquid apart.

→ Hydraulic-Ram Pumps — In these pumps kinetic energy of a low head water supply is stored temporarily in an air bubble hydraulic accumulator, then used to drive water to a higher head.

Power for Pumping :-

1. Electric Motors — Motor drive is very convenient for simple and durable centrifugal pumps.

2. Gasoline Engines — The operational cost of these engine is so high that these are uneconomical and hence used in case of emergencies.

3. Steam Engines — Now a days electricity has largely replaced steam engines for water supply. Steam engine is suitable at such places where fuel is very cheap.

4. Diesel Engine — The initial cost ~~of~~ of these engine is very high, they are difficult to start and their speed is very low. These engine required ~~to~~ separate electro-storage battery and compressed air for starting. There are large no. of moving parts in diesel engines.

Therefore it means experience operator to operate it. The maintenance cost of these engine is less but due to the above difficulties these are not commonly used in water pump.

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WATER WASTE ENGINEERING
SECTION-B

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06. INTRODUCTION

NOTES

→ In every town or city used water from bathroom, kitchens, house and street washing, waste water from industries, semi-liquid wastes from human and animals ~~ext~~ excreta, dry refuse of house and street sweeping, etc are produce daily.

→ Hence proper arrangment for the collection, treatment and disposal of the wastes have to be done.

* Definition of common terms used in sanitary Engineering.

1. 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.

2. 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.

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3. Soil Pipe :- The term soil pipe is used to indicate the pipe which carries discharge from soil fittings such as urinals, water closets, etc.

4. Vent Pipe :- The pipe installed for the purposes of ventilation is known as Vent pipe.

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

6. Bacteria :- These are microscopic unicellular plants or organisms. These are divided into three groups :- namely, aerobic, anaerobic and facultative.

The 'aerobic bacteria' require light and free oxygen for their existence and development.

The 'anaerobic bacteria' do not require light and free oxygen for their existence and development.

The facultative bacteria can exist in presence or absence of oxygen but they grow in plenty in absence of air.

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7. Invert :- The lowermost level or surface of a sewer is known as its inverts.

8. 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 : The term garbage is used to indicate dry refuge 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 building, institutions

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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 rain water of the locality

(d) Subsoil water : This indicates the ground water which finds its entry into sewers through leaks.

(e.) Sullage : The term sullage is used to indicate the waste water from bathrooms kitchens, etc

9. Sewer :- The underground conduits or drains through which sewage is conveyed are known as sewers.

Following terms are used in practice in connection with different types of sewers:-

(a.) Branch or sub main sewer : The sewer which obtains its discharge from a few laterals and delivers it to the main sewer is known as branch sewer.

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(b.) Combined sewer : The sewer which carries domestic sewage and storm water is known as a combined sewer

(c) Common sewer : The sewer on which all the inhabitants have equal legal rights is known as common sewer.

(d) Depressed sewer : when an obstruction or obstacle is met with, the sewer is constructed lower than the adjacent sec-tions to overcome the obstruction or obstacle. Such a portion or section of sewer is known as 'depressed sewer'.

(e) 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

(f) Lateral sewers : The sewer obtaining its discharge directly from buildings is known as 'lateral sewer'.

(g) Main sewer : The sewer which obtains its discharge from a few branch or submain sewers, is known as main sewer.

(h.) Outfall sewer : The length of main or

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trunk sewer between the connection of lowest branch and final point of disposal is known as outfall sewer.

(i) Relief or overflow sewer : The sewer which is meant to carry the excess discharge from an existing sewer is known as a relief sewer.

(j) Trunk sewer : The sewer which obtains its discharge from two or more main sewers is known as a trunk sewer.

10. Sewerage :- The entire science of collecting and carrying sewage by water carriage system through sewers is known as a trunk sewer.

11. Rubbish :- All sundry solid wastes as paper, broken furnitures, pottery, waste building materials, etc. are known as rubbish.

DWF (Dry weather flow)

Dry weather flow is normal flow available in any season. It is due to sanitary sewage.

DWF is generally $\frac{1}{20}^{th}$ or $\frac{1}{25}^{th}$ of max

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flow during monsoon.

Systems of Sewage

1. Separate system :- Sanitary sewage and storm water are collected, conveyed and disposed off separately. (e.g - Mumbai)

→ Suitability :

i. In areas of uneven rainfall in a year.

ii. In hilly areas with steep slopes.

iii. Where deep excavations cannot be easily done.

2. Combined system :- Both sanitary sewage and storm water drainage are collected in the same pipe (e.g → Chennai)

→ Suitability :

i. When rainfall is evenly distributed through out the year.

ii. In plain areas where excavation is easy and less costly.

iii. When area is congested or for narrow streets.

3. Partially separate system

Design for carrying sewage discharge plus part of the storm sewage from the roofs and court yard (eg- Banglore)

Classifications of sewers

1. House sewer

Sewer pipe carrying sewage from a building to the point of its immediate disposal

The sewerage system originate from it

2. Lateral sewer

A sewer which receives the discharge from number of independent houses is known as Lateral sewer.

These are also known as Branch sewers or sub-mains.

3. Trunk OR Main sewer.

These are the main sewers to which lateral sewers are connected.

4. Out-fall sewer

The sewer which transports the sewage to the point of treatment and from the treatment plant to the disposal point

Sewage treatment plant should generally be located in low ~~line~~ a lying areas.

As far as possible the sewers should be designed to flow under gravity with half or $\frac{3}{4}$th full.

Estimation of Dry Weather Flow.

Dry weather flow depends on per capita water supply.

Usually 70 to 80 % of supplied water is converted to waste water ~~it~~ and reaches the sewer.

Q_{DWF} = Population x Per capita sewage flow

Per capita sewage flow = Per capita water supplied x factor

Factor = 0.7 * 0.8

→ (Fraction of supplied water converted into waste)

Q_{DWF} = Population × Per capita water supplied × Factor

Estimation of Wet Weather Flow.

Q_{WWF} → Due to storm water.

$Q_{WWF} = \frac{AIR}{360}$ m³/sec Valid for area ≤ 500 hectare

Here,
A - Area of catchment in hectares
I = Impermeability factor / Runoff factor

$I = \frac{A_1 \times I_1 + (A_2 \times I_2) + \ldots\ldots (A_i I_i)}{A}$

$= \frac{\Sigma (A_n I_n)}{A}$ (unit less)

R = Rainfall Intensity
= $\frac{\text{Amount of Rainfall}}{\text{Duration of Rainfall}}$
= $\frac{P}{t}$ mm/hr.

So, Rainfall Intensity is obtained using the formula

$R = \frac{25.4a}{t_c + b}$

'a' & 'b' are constants which depend upon

(t). " Duration of rainfall

→ For storm of Duration :-

i.) t = 5 min to 20 min
$a = 30$, $b = 10$.

ii.) $t > 20$ min
$a = 40$, $b = 20$.

t_c = time of concentration.

If 't' is not given, then you can consider $t = t_c$.

$t_c = t_e + t_f$

t_c = time of concentration.
Time taken by the drop of water from the farthest / remote point of catchment to reach the outlet

t_e = time of entry / inlet time (min)

t_f = Flow time (min) or time of flow.
Time taken to flow from the inlet to the point of concentration

$t_f = \frac{\text{Length of the drain}}{\text{Velocity of flow in the drain}}$

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Length of the drain = Distance travelled in the drain.

Combined system

$Q = Q_{DWF} \times Q_{WWF}$

Shapes of Sewer.

1. Rectangular

A rectangular shaped sewer is a large sewer mostly used for carrying a large quantity of sewage, it is also used for discharging stormed water.

The section of rectangular sewer is very stable as compare to the section of other sewer

As they are rectangular in shape the upper and invert both portions are flat

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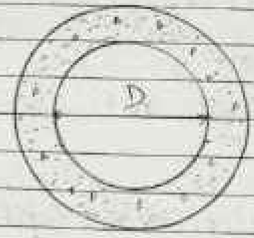
2. Circular shape sewer

It is mostly used sewer and is preferred for all types of sewage.

This shape of sewer is easy to construct require less construction material and it economical.



Circular geometric cross-sections are preferred to other as circular sections are hydraulically more efficient.

Circular sections are stream-lined and

Que. A city with a population of 100000 has an area of 100 hectares (Ha) then rate of supply of water is equal to 200 LPCD and average runoff coefficient for entire area is equal to 0.5, time of concentration is equal to 15 min. Assume 75% of water supply reaches the sewer. Find DWF and WWF

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Soln:- Given,
Population = 100000
Area - (A) = 100 hectares
Per Capita water supplied = 200 lpcd.
Runoff factor (I) = 0.5
Time of concentration (t_c) = 15 min
Factor = 75% = 0.7

$1 m^3 = 1000 l$

$1 l = \frac{1}{1000} m^3$

$\therefore 200 l = \frac{200}{1000} m^3$

Q_{DWF} = Population × Per Capita water supplied × Factor

$= 100000 \times \frac{200}{1000 \times 24 \times 60 \times 60} \times 0.75$

$= 0.173 \ m^3/sec$

$Q_{WWF} = \frac{AIR}{360}$

NOTE :- In case of when storm of duration is not given in question then:-
$t = t_c$

$\therefore R = \frac{25.4a}{t_c + b}$

$= \frac{25.4 \times 40}{50 + 20}$

$= 14.51$

Hence, $t > 20$ min.
$\therefore t = 50$ min.
$a = 40$ & $b = 20$

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$Q_{WWF} = \frac{100 \times 0.5 \times 14.51}{360} = 2.015 \ m^3/sec$

$\therefore Q = Q_{DWF} + Q_{WWF}$
$= 0.173 + 2.015$
$= 2.188 \ m^3$.

Design Of Sewers

Sewers are designed as Open-gravity fed Conduits / Channels.

→ Design of sewers include :-

1. Fixing the Cross-section

$Q = A.V$

11. Fixing the gradient.

$V = \frac{1}{n} \times R^{2/3} \times S^{1/2}$ → Manning's formula

$V = C\sqrt{RS}$ → Chezy's formula

Here,
n = Manning's formula
R = Hydraulic mean depth.

$R = \frac{Area}{\text{wetted perimeter}}$