Ch-1 **Introduction :-** Dt - 15/01/19

Importance & Necessity for ~~planned~~ planned water supply:-

Water basically present in 3 states.
(I) solid - Snow, ice, Glacier
(II) Liquid - Sea, river, lake, pond
(III) Gaseous - water vapour

→ Water is present in 2/3 of human body.

→ Water should be good and shouldn't contain unwanted impurities, harmful chemical or bacteria.

→ To ensure availability of sufficient quantity of good quality water, it is essential to plan and built suitable water supply scheme to provide potable (safe to drink) water to various section of community as per their demands and requirements.

→ These water supply scheme provide water for the purpose of drinking, cooking, bathing, washing and promoting batter help & hygiene.

→ To supply water for fountain in parks, gardening, fire fighting.

→ To promote sanitation & beautification & reduce environment pollution.

→ To attract industries requiring huge quantity of water.

Water demand:

To evaluate the amount of water available and the amount of water demanded by public.

It has two major states –

(I) To consider demand and compute the quantity of water required.

(II) To find the sources to fulfil that demand.

If demand > sources than compromise is done.

Quantities to be assessed for water supply scheme:

~~Various types of water demand:~~

While planning water supply scheme following quantities are assessed and recorded.

(I) Total annual volume (V) in l, Ml (million l)

(II) Annual avg. rate of flow or draft in lpd (litres per day), i.e, $\frac{V}{365}$.

(III) Annual avg. rate of flow in lpcd (litres per capital per day)
(Per capital demand (q) -

(iv) Avg. rate of flow in L/day/service

i.e., $\frac{V}{365} \times \frac{1}{\text{no. of service}}$

(v) Fluctuations in flow in terms of percentage ratios of maximum or minimum yearly, monthly, daily or hourly rates to their corresponding avg. values.

~~Various~~

① Domestic water demand—

This is the water demand in private building for drinking, cooking, bathing, gardening, sanitary purpose etc.

minimum domestic water consumption (annual avg.) for Indian towns and cities with full flushing system as per IS 1172-1993 (HIG) Higher Income group.

Use	Consumption in lpcd
1. Drinking	5~~675~~
2. Cooking	5
3. Bathing	75
4. Washing clothes	25
5. Washing Utensils	15
6. Washing & cleaning of houses	15
7. Lawn watering & Gardening	15
8. Flushing of W.C	45
	200

Minimum domestic water consumption (Annual avg.) for weaker section (LIG) in small Indian towns & cities -

Use	Consumption in lpcd
I. Drinking	5
II. Cooking	5
III. Bathing	55
4. Washing clothes	20
5. Washing Utensils	10
6. Washing & cleaning of houses	10
7. Flushing of W.C	30
	135

Domestic water consumption is 50-60% of total water consumption.

→ Total Domestic water demand = Total design population × per capital domesti consumption.

→ ② **Industrial water demand** -

It represents water demand of industries, existing or lightly to be set up in near future.

→ It is 50lpcd for normal industri requirement.

→ For industrial cities it is 450lp

Water demand for important industry.

Name	Water requirement in (kl/ unit of production).	
1. Automobile	40	
2. Distillary	122 - 170	
3. Fertilizer	80 - 200	
4. ~~Leather~~ Leather	40	
5. Paper	200 - 400	200 to 1000
6. special quality paper	400 - 1000	
7. strow board	75 - 100	
8. Petroleum refinary	1 - 2	
9. Steel	200 - 250	
10. Sugar	1 - 2	
11. Dextile	80 - 140	

③ Institutional & commercial water demand

20 lpcd is taken for an avg. city
For highly commercialized city 50 lpcd is taken.

Demand for public use -

Normally 5% of total consumption is taken.
For computing total water requirement 10 lpcd is taken.

(at least 3 types of jet
used)

④ **Fire demand** –

Fire hydrants are fitted in water mains at 100 to 150 m apart.

Minimum water pressure available should be 100–150 kN/m² for 4 to 5 hrs constantly.

Emperical formula for fire demand

① **Kuichling's formula** –

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

where Q – amount of water required in l/min

P – Population in thousands

② **Freeman formula** –

$$Q = 1136 \times \left(\frac{P}{10} + 10\right)$$

~~National Board of fire under writter's formula~~ –

③ **Boston's formula** –

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

(v) **Water demand in losses in thaft and waste** –

Leakage, bed plumbing, damaged meter, stolen water & other losses

It is 15% of total consumption or 55 lpcd is normally taken.

Break up of per capital(q) demand for an avg. Indian city –.

Use	Demand in lpcd
1. Domestic	200
2. Industrial	50
3. Commercial	20
4. Civic or public	10
5. Waste & theft	55
	335 lpcd

per capital demand(q)

Per capital demand (q) –

It is the annual avg. amount of daily water required by one person and includes domestic, industrial & commercial use, public used, waste & theft etc. It is expressed as

Imp

$$\text{per capital demand}(q)\text{ in lpcd} = \frac{\text{Total yearly water requirement of the city in litres }(V)}{365 \times \text{design population}}$$

Factores affecting Per capital demand.

(I) Size of the city
(II) Size of population
(III) Climatic condition
(IV) Social & economic status & habits ~~some~~ of people.
(V) industrial & commercial activity
(VI) Quality of water supply
(VII) Pressure in the distribution system
(VIII) Development of sewarage facility
(IX) System of supply
(X) Cost of water
(XI) Metering policy & method of charging
(XII) Age of community.

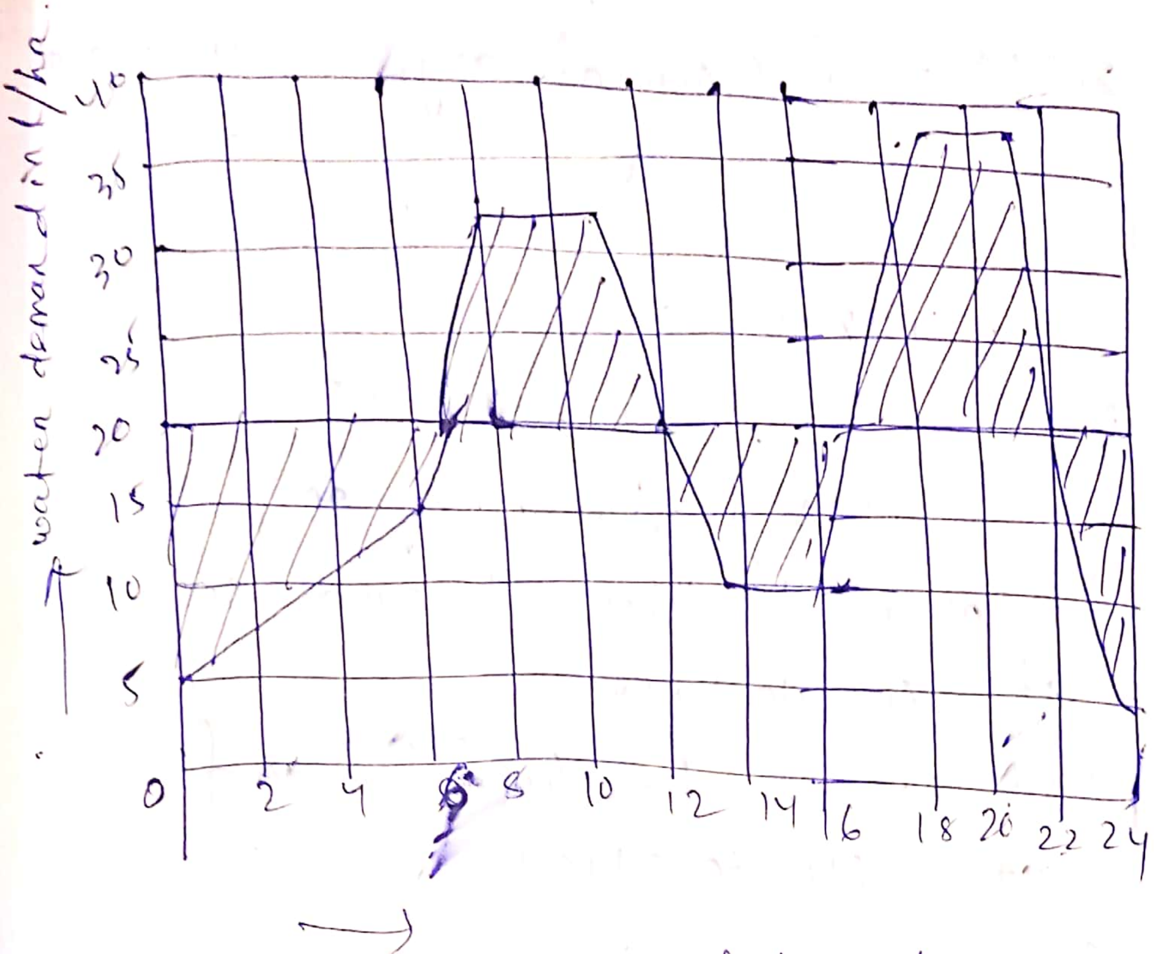
Variation in demand –

(I) Seasonal variation
(II) Day to Day or Daily variation
(III) Hourly variation

(8 to 11 am) water consum is at peak).
(7pm to 9pm)
~~Night flow~~

Night flow –

It represents magnitude of losses and waste as there is no appreciable domestic consumption during this time.



Showing hourly rate of water consumptions.

Assessment of Normal variation —

① **Maximum daily consumption:** —

Maximum daily demand = 1.8 × avg. daily demand

$= 1.8 \times q$

⑪ **Maximum hourly consumption:** —

It is the maximum hourly consumption of maximum day. That is peak demand.

$= 1.5 \times$ avg. hourly consumption of the maximum day.

$= 1.5 \times \frac{\text{maximum daily demand}}{24}$

$= 1.5 \times \frac{1.8q}{24} = \frac{2.7q}{24}$

$\frac{2.7 \times q}{24} = 2.7 \times$ Annual. avg. hourly demand

Maximum monthly consumption -

$= 1.28 \times q$

Maximum weekly demand -

$= 1.48 \times$ Avg. weekly demand

Maximum hourly demand is at 8 AM to 11 AM.

2nd highest hourly demand at 6 PM to 8 PM

Coincident Draft -

It is the maximum of

① Maximum daily demand + Fire demand

② Maximum hourly demand

Effect of variation in demand on design capacity of various components of water supply schem

① Source of supply are designed for maximum daily consumption.

② Main pipe lines are designed for maximum daily consumption.

③ Filters and other units are designed for maximum daily demand.

④ Pumps are designed for max^m daily demand.

⑤ Distribution system designed for max^m hourly demand of max^m day or coincident draft which ever is greater.

⑥ Service reservoir are designed for max^m daily demand.

Design Period of water supply units as per govt. of India man work on water supply –

Water supply unit		Design period
1. Storage by dams & Reservoir	-	50 yrs
2. Infilteration works	–	30 yrs
3. Pumping		
(a) Pump house	–	30 yrs
(b) Motor & Pump	–	15 yrs
4. Watere treatment unit	–	15 yrs
5. Pipe connection to treatment unit and other small parts	–	30 yrs
6. Raw water & clean water conveying unit	–	30 yrs

7. Clean wate reservoir, Service reservoir	15
8. Distribution system	30
9. Wells & tube wells	30 – 50 yrs

Population ~~pro~~forecasting method –

Q> A water supply scheme has to be design for a city having population of 100000. Estimate the important kinds of drafts which may be required to be recorded for an avg. water consumption of 250 lpcd. Also ~~record~~ find out the required capacity of the major components of the proposed water work system for the city using river as the source of supply.

Ans –

Avg. Daily demand for 1 person for 1 Day = 250 lpcd

Daily demand for 1 Lakh person for 1 Day = 250×100000

$= 25 \times 10^6$ l/day

Avg. daily demand (q) = 25 Ml/day (million)

Max^m daily demand = $1.8 \times q$

$= 1.8 \times 25 \times 10^6$

= 45 M l/day

= 45000000

Max^m hourly demand for max^m day ~~demand~~

$$= \frac{2.7 \times q}{24}$$

$$= \frac{2.7 \times 25}{24}$$

$$= 2.8125 \text{ Mld}$$

$$= 2.8125 \times 10^6 = 2812500 \text{ ld}$$

Fire demand -

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

$$= 3182\sqrt{100}$$

$$= 3182 \times 10$$

$$= 31820 \text{ l/min}$$

$$= 31820 \times 24 \times 60$$

$$= 45820800 \text{ ld}$$

Coincident draft -

(a) maximum daily demand + fire demand

$$= 45000000 + 45820800$$

$$= 90820800 \text{ ld}$$

① Arithmatic increase method -

This method is based on the assumption that the population increases at a constant rate.

The rate of change of population with time $\left(\frac{dp}{dt}\right) = \text{const. } K$

· mathematically,

$$P_n = (P_0 + n\bar{x})$$

P_n = Prospective or forecasted populati after n decades from present (last known census)

P_0 = Population at present (last known census)

n = no. of decades between present & future.

$\bar{x}$ = Arithmatic mean of population increase in the known decades

Q) The population of 5 decades from 1930 to 1970 are given below. Find the population after 1, 2 & 3 decades beyond the last known decad. By using arithmatic increase method.

Year	1930	1940	1950	1960	1970
Popⁿ	25000	28000	34000	42000	47000

Ans- $P_0 = 47000$

Year	Population	Increase in populatio
1930	25000	
		3000
1940	28000	
		6000
1950	34000	
		8000
1960	42000	
		5000
1970	47000	
		total = 22000

Avg. increase per decade $\bar{x} = \frac{22000}{4}$

$= 5500$

population after 1st decade beyond 1970

$P_n = (P_0 + n\bar{x})$

$P_{1980} = (47000 + 1(5300))$

$= 52500$

population after 2nd decade beyond 1970

$P_{1990} = (47000 + 2(5500))$

$= 58000$

population after 3rd decade beyond 1970

$P_{2000} = (47000 + 3(5500))$

$= 63500$

② Geometric increase method -

In this method the per decade % increase or percentage growth rate (r) is assumed to be constant and the increase is compounded over the existing population every decade. So this method is also called uniform increase method.

The basic difference between arithmatic increase & Geometric increase method is, In arithmatic increase no compounding is done and in geometric increase method compounding takes place every decade.

mathematically,

$$\boxed{P_n = P_0 + \left(1+\frac{r}{100}\right)^n}$$

P_0 = initial population

P_n = future population after n decade

r = assume growth rate in %

r can be foundout by —

① **1st method** -

$$r = \sqrt[t]{\frac{P_2}{P_1}} - 1$$

P_1 = Initial known population

P_2 = final known population

t = no. of decades betn P_1 & P_2

② **2nd method** -

To compute the avg. of % growth rate of the served known decades of the past.

The growth rate $\left(\frac{\text{increase in population}}{\text{original population}} \times 100\right)$

values are computed for each decade and their avg. are taken as constant per decade increase(r).

The avg. taken is by either arithmatic mean or geometric mean.

Arithmatic mean –

$$\frac{r_1 + r_2 + \dots + r_t}{t}$$

Geometric mean –

$$\sqrt[t]{r_1 \times r_2 \times r_3 \times \dots \times r_t}$$

Arithmatic mean is taken in the field by design engineers because it gives higher value than geometric mean.

→ But as for govt. of India manual on water supply the geometric mean method is rekommended. so it is used frequently.

Q4)

Year	Population	Increase in population in each decades	Percentage increase in population growth rate (r)
1930	25000	3000	$\frac{3000}{25000} \times 100 = 12$
1940	28000	6000	21.43
1950	34000	8000	23.53
1960	42000	5000	11.90
1970	47000		
		22000	

$$r = \sqrt[t]{r_1 \times r_2 \times \cdots \times r_t}$$

$$= \sqrt[4]{12 \times 21.43 \times 23.33 \times 11.90}$$

$$= 16.38\% \text{ per decade}$$

Assuming that future population increases at its constant rate (16.37%

we have.

(i) Population after 1st decade after 1970

$$P_n = P_0 \left(1 + \frac{r}{100}\right)^n$$

$$P_{1980} = 47000 \left(1 + \frac{16.37}{100}\right)^1$$

$$= 54694$$

(ii) $$P_{1990} = 47000 \left(1 + \frac{16.37}{100}\right)^2$$

$$= 63647$$

(iii) $$P_{2000} = 47000 \left(1 + \frac{16.37}{100}\right)^3$$

$$= 74066$$

Q) Compute the population of the year 2000 & 2006 for a city whose populati in the year 1930 was 25000 & in the year 1970 was 47000 make use of geometric increase method.

Ans- $P_1 = 25000$

$P_2 = 47000$

$t = 1970 - 1930 = 4$

$$r = \sqrt[t]{\frac{P_2}{P_1}} - 1$$

$$= \sqrt[4]{\frac{47000}{25000}} - 1$$

$$= 0.1709 \times 100$$

$= 17.09$ per decade

$$P_{2000} = P_0 \left(1 + \frac{r}{100}\right)^n$$

$$= 47000 \left(1 + \frac{17.09}{100}\right)^3$$

$$= 75450$$

$$P_{2006} = P_0 \times \left(1 + \frac{r}{100}\right)^n$$

$$= 47000 \times \left(1 + \frac{17.09}{100}\right)^{3+\frac{6}{10}}$$

$$= 47000 \times \left(1 + \frac{17.096}{100}\right)^{3.6}$$

$$= 82953$$

Q) Determine the future population of a satellite town by the geometric increase method. For the year 2011 given the following data.

Year	1951	1961	1971	1981	.....	2011
population in thousand	93	111	132	161	....	?

Ans

Year	Population	Increase in population	% increase population
1951	93000	18000	19.35
1961	111000	21000	18.92
1971	132000	29000	21.97
1981	161000		

$$r = \sqrt[t]{r_1 \times r_2 \times r_3 \cdots \times r_t}$$

$t = 3$

$r = 20.03\%$ per decade.

$$P_{2011} = P_0\left(1+\frac{r}{100}\right)^n \quad n = 3$$

$$= 161000\left(1+\frac{20.03}{100}\right)^3$$

$$= 278416$$

Assignment

Q) Describe arithmatic, increase method and Geometric increase method of population fore casting with an example.

Dt - 30/1/19

→ The population statistics pertaining to a town are given below. Estimate the population expected in 1980 by arithmatical & geometric increase method.

Year	Population
1930	70000
1940	100000
1950	150000
1960	200000
1970	240000

Year	population	Increase in population	% increase in population growth rate (r)
1930	70000	30000	42.86
1940	100000	50000	50
1950	150000	50000	33.33
1960	200000	40000	20
1970	240000		
		170000	

Arithmatic increase method –

Avg. increase $\bar{x} = \frac{170000}{4} = 42500$

$P_n = (P_0 + n\bar{x})$

$P_{1980} = 240000 + 1(42500)$

$= 282500$

Geometric mean method —

$$r = \sqrt[t]{r_1 \times r_2 \times \cdots \times r_t}$$

$$= \sqrt[4]{42.86 \times 50 \times 33.33 \times 20}$$

$$= 34.57\ \%\ \text{increase per decade}$$

$$P_n = P_0\left(1 + \frac{r}{100}\right)^n$$

$$P_{1980} = 240000\left(1 + \frac{34.57}{100}\right)^1$$

$$= 322968$$

Method of varying increament or increamental increase method :—

In this method the per decade growth rate is not assumed to be constant, but is progressively increasing or decreasing depending upon whether the avg. of the increamental increase in the past data is +ve or −ve.

$$\boxed{P_n = P_0 + n\bar{x} + \frac{n(n+1)}{2}\bar{Y}}$$

$\bar{x}$ = Avg. increase in population of known decade

$\bar{Y}$ = Avg. of increamental increase of the Known decades.

N.B.

This method will give result which fall between the results of arithmatic increase and geometric increase method. So this method gives satisfactory result.

Q1

Year	1930	1940	1950	1960	1970
Popn	25000	28000	34000	42000	47000

Increase in popn	3000	6000	8000	5000

total = 22000

$$\bar{x} = \frac{22000}{4} = 5500$$

Increamental increase or increament on the increase
+ 3000
+ 2000
− 3000
+ 2000

$$\bar{Y} = \frac{2000}{3} = +667$$

$$P_n = P_0 + n\bar{x} + \frac{n(n+1)}{2}\bar{y}$$

$n=1$

$$P_{1980} = 47000 + 1 \times 5500 + \frac{1(1+1)}{2} \times 667$$

$$= 53167$$

$n=2$

$$P_{1990} = 47000 + 2 \times 5500 + \frac{2(2+1)}{2} \times 667$$

$$= 60001$$

$n=3$

$$P_{2000} = 47000 + 3 \times 5500 + \frac{3(3+1)}{2} \times 667$$

$$= 67502$$

Note -

Geometric increase method is suitable for new cities expanding at faster rate. For old cities arithmatic method is used.

Increamental method is used for both old & new cities.

Q)

Census Year	Population
1880	8000
1890	12000
1900	17000
1910	22500
1920	29000
1930	37500
1940	47000
1950	57000
1960	66500

Estimate the population of the locality in 1980 by increamental increase method.

Census Year	Population	Increase in population.	Increamental increase
1880	8000	4000	+1000
1890	12000	5000	+500
1900	17000	5500	+1000
1910	22500	6500	+2000
1920	29000	8500	+1000
1930	37500	9500	+500
1940	47000	10000	-500
1950	57000	9500	
1960	66500		

$\bar{x} = \frac{58500}{8} = 7312$ $\bar{Y} = \frac{5500}{7} = 786$ 5500

$$P_n = P_0 + n\bar{x} + \frac{n(n+1)}{2}\bar{y} \qquad n=2.$$

$$P_{1980} = 66500 + 2(7312) + \frac{2(2+1)}{2} \times 786$$

$$= 83482$$

Q) In a town it has been decided to provide 200l per head per day in 21st century. Estimate the domestic water requirement of this town in the year 2000 AD by projecting the population of the town by incremental increase method?

Year	population
1940	2,37,98,624.
1950	4,69,78,325
1960	5,47,56,437
1970	6,34,67,823
1980	6,90,77,421

Census Year	Population	Increase in population	Incremental Increase
1940	23798624	2,31,79,701	
1950	46978325	77,78,112	−15401589
1960	54756437		933274
1970	63467823	87,11,386	−3101788
1980	69077421	56,09,598	
		$\Sigma X = 45278797$	$\Sigma y = -17570103$

$\bar{X} = \frac{45278797}{4}$

$= 11319699.25$

$\bar{Y} = \frac{-17570103}{3}$

$= -5856701$

$P_0 = 69077421 \qquad n = 2$

$P_{2000} = P_0 + n\bar{x} + \frac{n(n+1)}{2}\bar{y}$

$= 69077421 + 2 \times 11319699.25 + \frac{2(2+1)}{2}(-5856701)$

$= 69077421 + 22639398.5 + -17570103$

$= 74146716.5$

$= 74146716$

Total water requirement

$= 74146716 \times 200 = 1.48 \times 10^{10}$

$= 14829.343900$ lpcd

$= 14829.34$ M.l per per d.

Decreasing rate of growth method

Since the rate of increase in population goes on reducing as the city reaches its saturation value, a method which makes use of the decrease in percentage increase is used.

In this method avg. decrease in % increase is found out and subtracted from latest % increase for each successive decades. This method is applicable only in the case where rate of growth shows a downward trend.

Year	Population	Increase in population	% increase in popn	Decrease in the % increase
1930	25000	3000	$\frac{3000}{25000} \times 100 = 12\%$	-9.40%
1940	28000	6000	$\frac{6000}{28000} \times 100 = 21.4\%$	-2.1%
1950	34000	8000	$\frac{8000}{34000} \times 100 = 23.5\%$	$+11.6\%$
1960	42000	5000	$\frac{5000}{42000} \times 100 = 11.9\%$	
1970	47000			
	Total =	22000		$-11.5+11.$ $= 0.1\%$

$$\text{Avg. per decade} = \frac{0.1}{3} = 0.033\%$$

(a) The expected population at the end of year 1980.

$$= 47000 + \frac{11.9 - 0.03}{100} \times 47000$$

$$= 47000 + \frac{11.07}{100} \times 47000$$

$$= 47000 + 5203 = 52203 \text{ Ans}$$

(b) The expected population at the end of year 1990.

$$= 52203 + \frac{11.87 - 0.03}{100} \times 52203$$

$$= 52203 + \frac{11.84}{100} \times 52203$$

$$= 52203 + 6181 = 58384 \text{ Ans}$$

(c) The expected popⁿ at the end of year 2000.

$$= 58384 + \frac{11.84 - 0.03}{100} \times 58384$$

$$= 58384 + \frac{11.81}{100} \times 58384$$

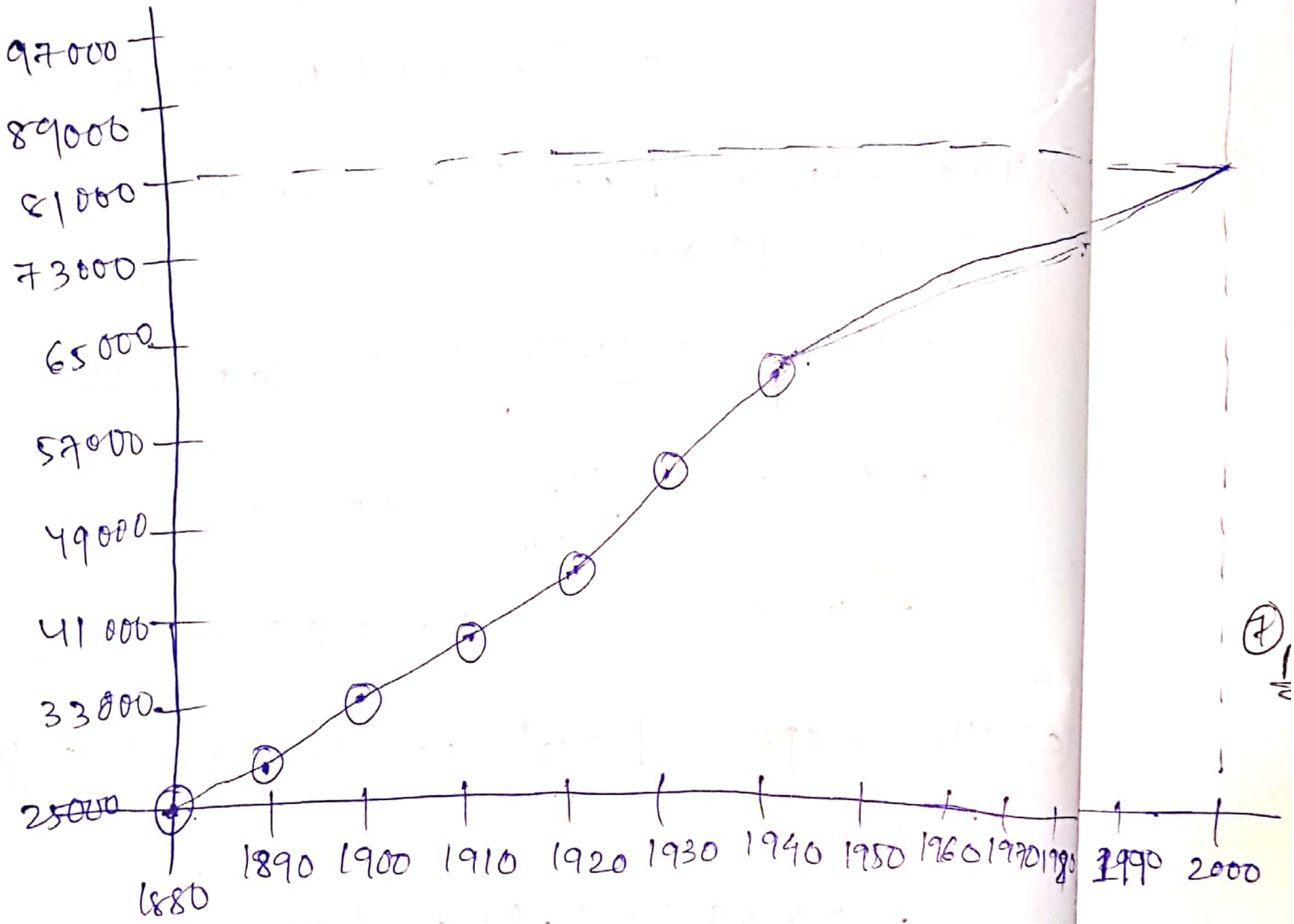
$$= 58384 + 6895 = 65279 \text{ Ans}$$

6/2/19

⑤ Simple graphical method –

The graph plotted using available data and curve and is smoothley extended to desired year.

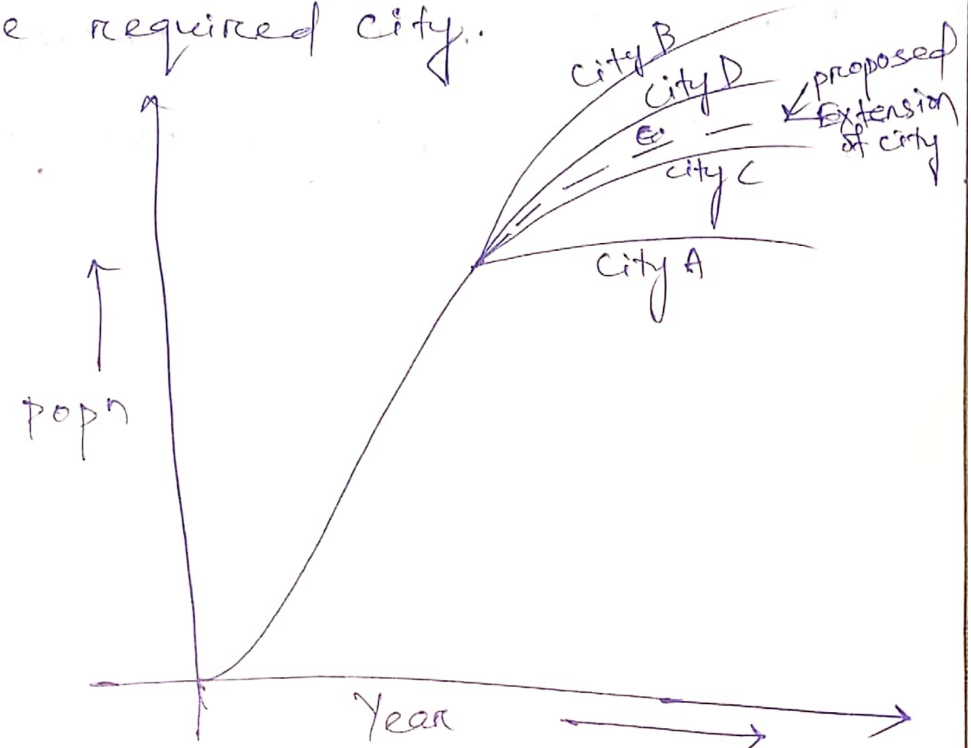
It is suitable when available data are of long period and projection required for short period.



Yr	Popⁿ
1880	25000
1890	27500
1900	33000
1910	39000
1920	45000
1930	54500
1940	61000

⑥ Comparative graphical method -

Cities of similar condition and characteristics are selected which have grown in similar fashion in past and graphs plotted, the mean graph from available data is used for the required city.



⑦ Master plan or ~~Zo~~ Zoning method-

Big and metropolitan cities are controlled by development authorities in a planned manner, so only those expansions are permitted as per master plan. So, if x no. of flats are to be constructed in the next decade and maximum of 4 nos of residents are allowed in a plan and then additional population allowed is $4 \times x$.

⑧ **Ratio method or apportionment metho**

Population of any town is expressed as percentage of population of whole country. And by taking avg. growth rate of country population, future population may be projected.

⑨ **Logistic curve method** -

Sources of water - ch-3

Dt - 6/2/19

① Surface water (pond, lake, streams, ocean river, storage reservoir)

(ii) Under Ground water

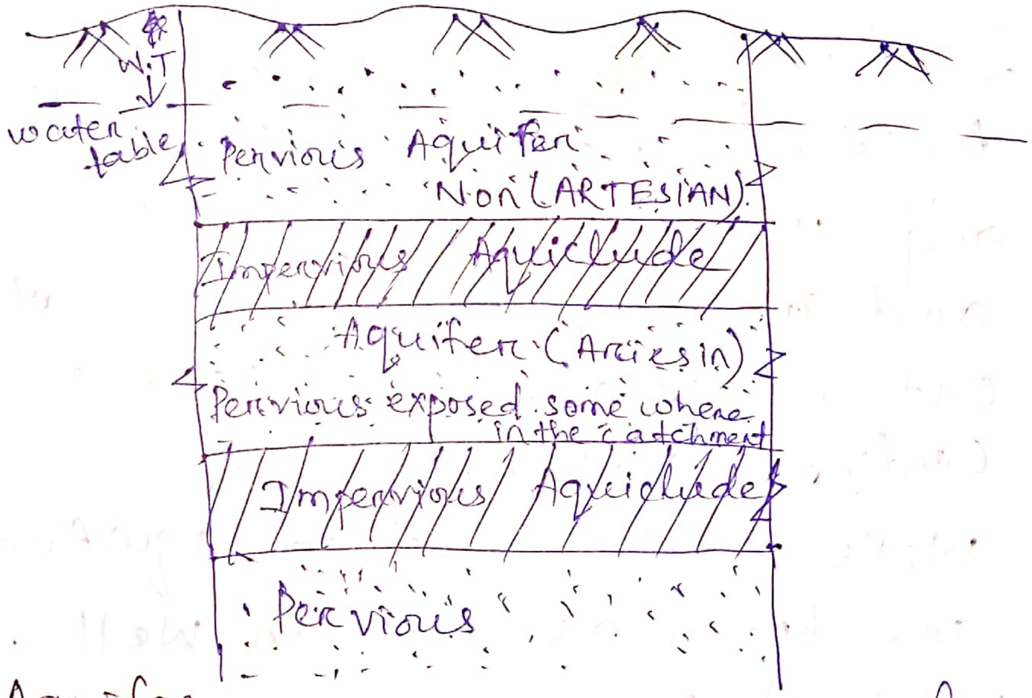
Subsurface water (Infiltration gallery, Infiltration well, wells & tube wells)

→ Algae weed — lake

River — Perrenial

River — Non-perrenial

Aquifer and their types -



Aquifer - Permeable stratum capable of building appreciable quantity of ground water under gravity is known as aquifeer.

When aquifeer is overlain by confined bed of impervious material then that confined bed is known as aquiclude.

Types -

(I) Unconfined / Non Artesian Aquifer -

Top most water bearing stratum having no confined impermeable over burden (aquiclude) laying over it, is known as unconfined aquifer.

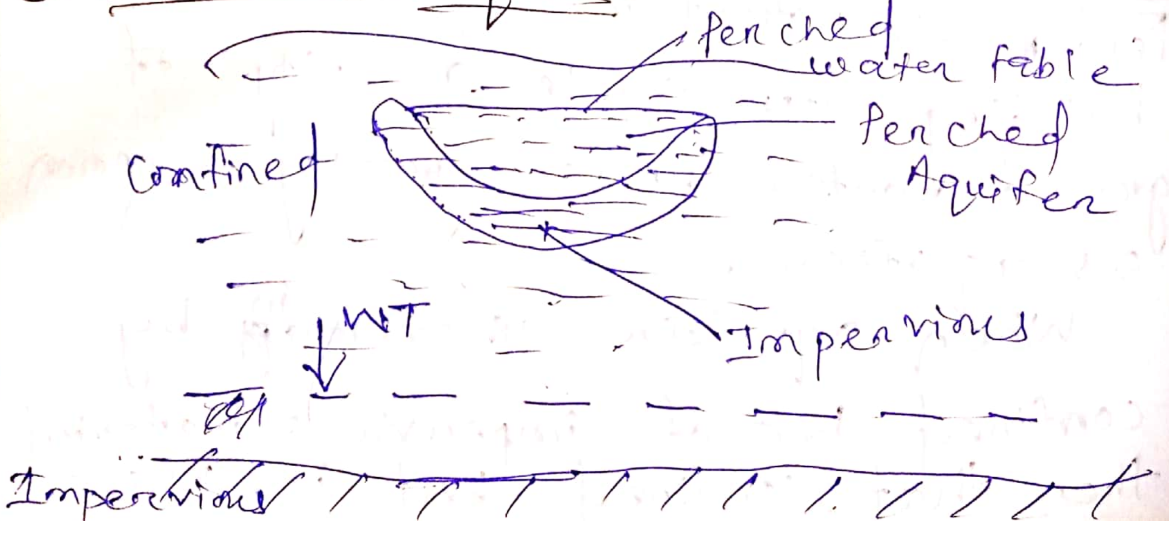
Wells in the unconfined aquifer are known as unconfined or Non Artesian ~~aquifer~~ well.

(II) Confined / Artesian Aquifer -

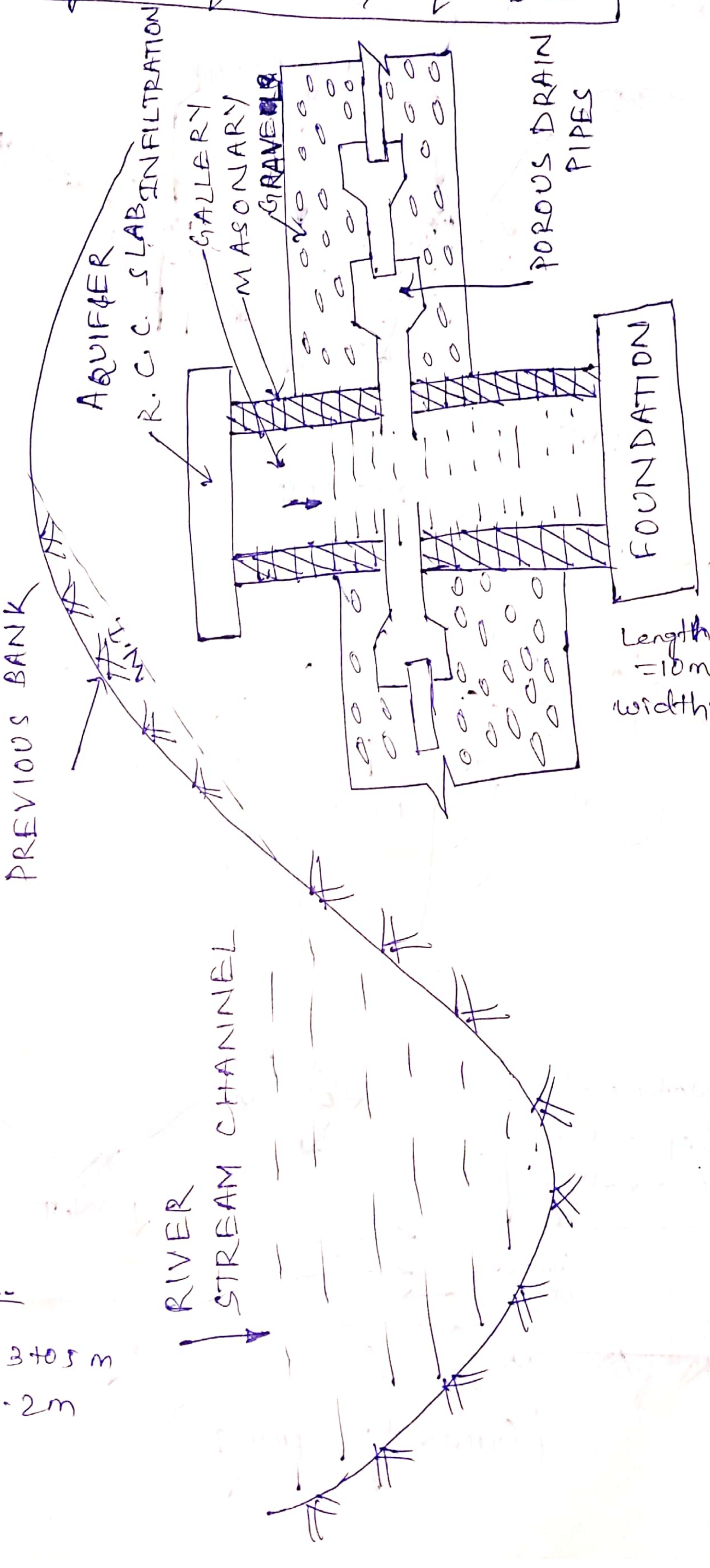
Aquifer confined on its upper and under surface by aquiclude and inclined to connected at catchment area is called confined aquifer.

Wells in the confined aquifer are known as Artesian Well.

(III) Perched Aquifer -



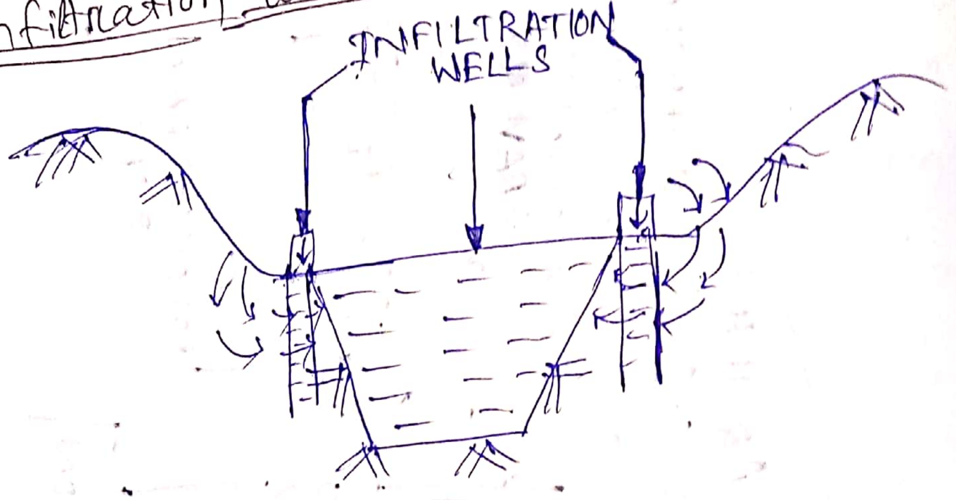
Aquifuge, Aquitard, Aquiclude.

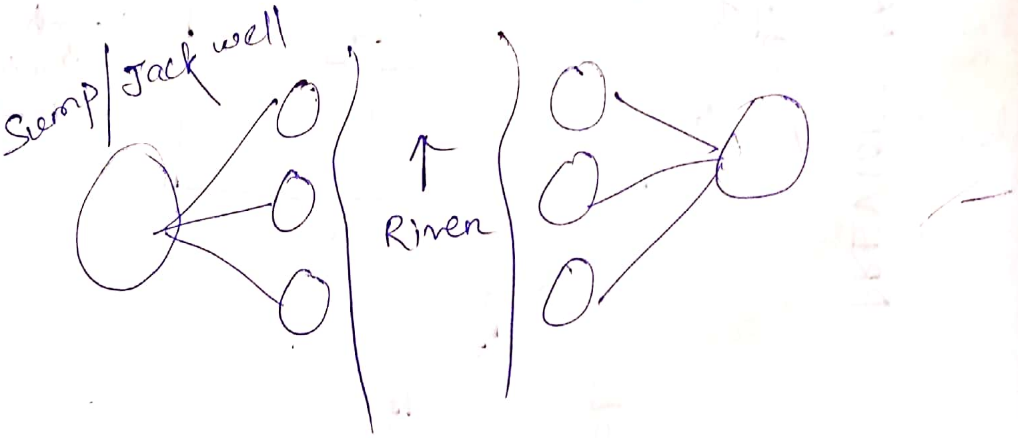


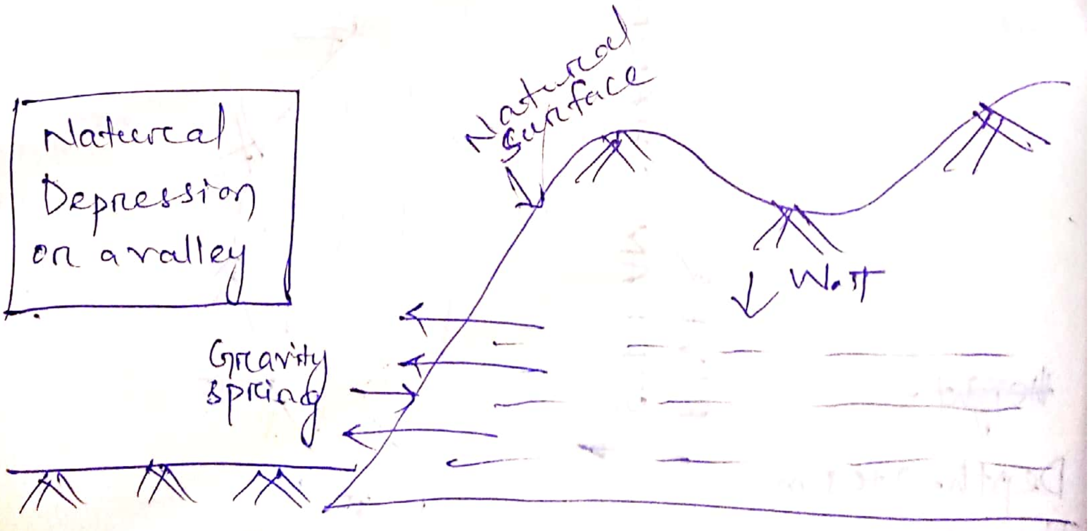
Length =10m to100m
width - 1m

~~Height~~
Depth - 3 to 5 m
Height - 2m

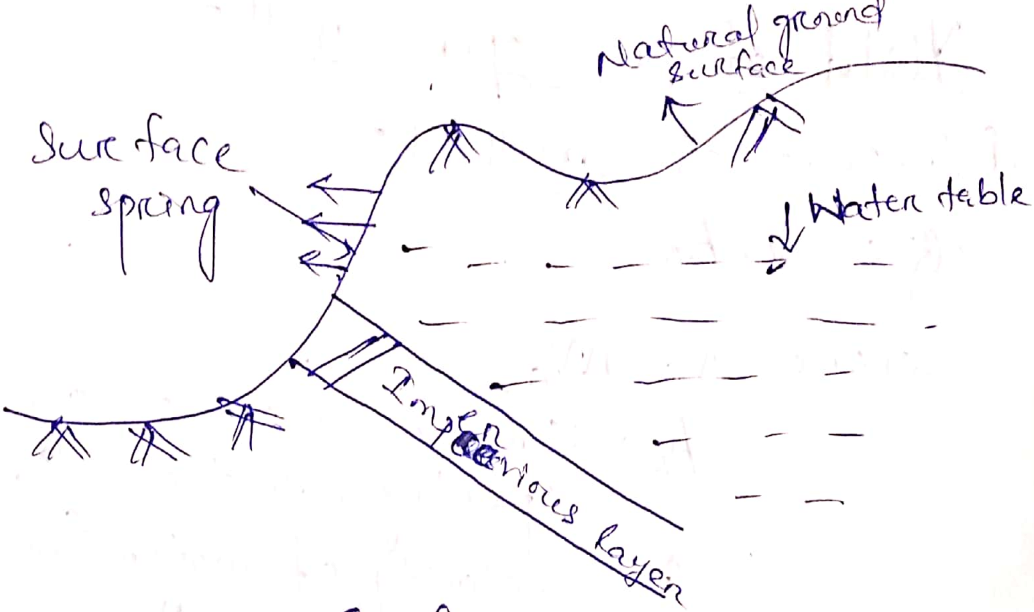
Infiltration well -



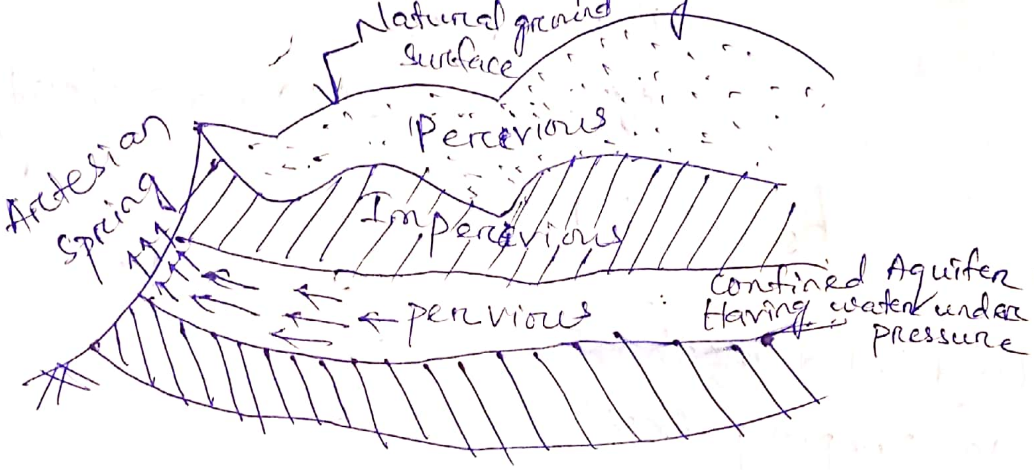




(Gravity spring)



Surface spring



(Artesian spring)

Spring -

The natural out flow of ground water at the earth surface is set to form a spring. A spring indicates the out cropping of the water table. Sometimes spring discharge hot water due to presence of sulphur in them.

There are 3 types of spring-

(I) Gravity spring
(II) Surface spring
(III) Artesian spring

Yield of an open well –

① Theoretical method –

$Q = v \cdot A_s$

where $v = nV_a$.

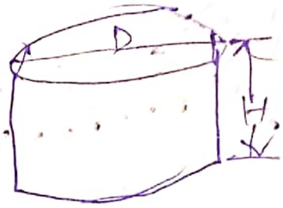
A_s = Surface area of a aquifer opening into the well.

v = velocity of water flowing into the well.

n = porosity

V_a = Actual flow velocity.

$A_s = \pi D H$



② Field method –

(a) Pumping test

(b) Recuperating test.

(a) Pumping test –

A pump is installed to draw sufficient supplies of water from the open well and to cause heavy draw down in its water level, the rate of pumping is then changed and so adjusted that water level in the well becomes constant. In this condition of equilibrium rate of pumping = The rate of yield

The yield is found out by <u>Darcy's formula</u> –

$Q = KiA$ $\quad$ i = slope

$= K\left(\frac{s}{L}\right) A$

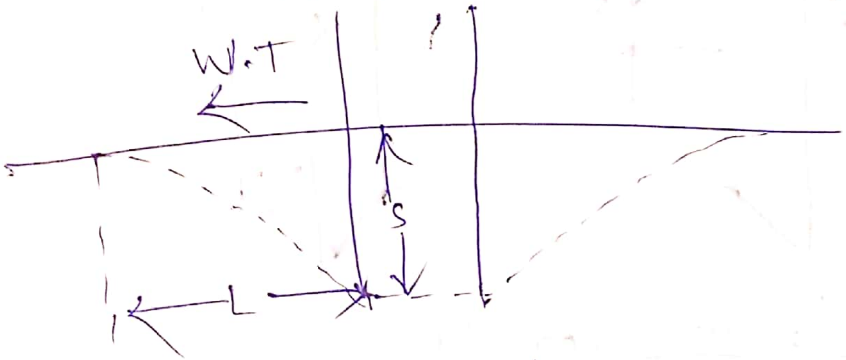
$= \frac{K}{L} . A . S$

$\Rightarrow Q = C . A . S$

where, S = depression head or draw down in the well

K = coefficient of permeability of hydraulic conductivity.

A = Area.



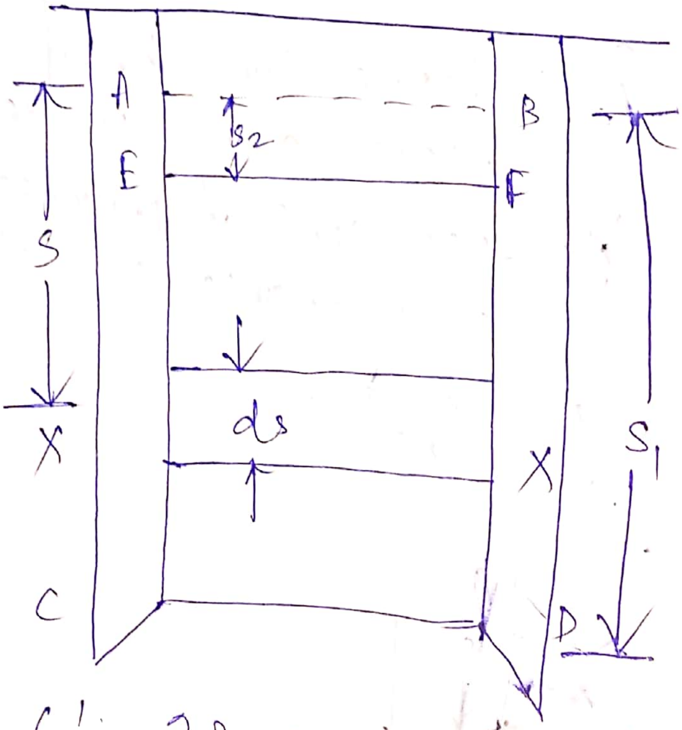
b) **Recuperating test** –

When it becomes difficult to adjust the rate of pumping so as to keep the well water level constant in such ~~tes~~' case Recuperating test is adopted.

In this method water is drained from the well at a fast rate to cause sufficient draw down then pumping stop. Then the water level will start raising.

Time taken for the water to come back

For open well -



$$\frac{C'}{A} = \frac{2.3}{T} \log_{10} \frac{S_1}{S_2}$$

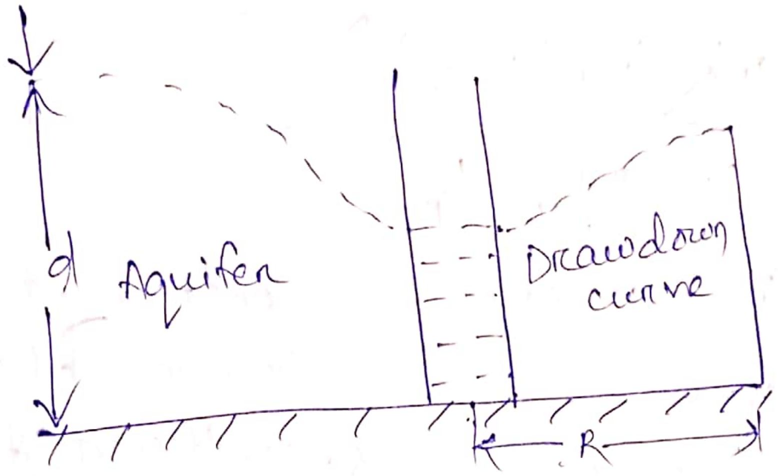
where $\frac{C'}{A}$ = Specific yield or Specificgrav of the open well

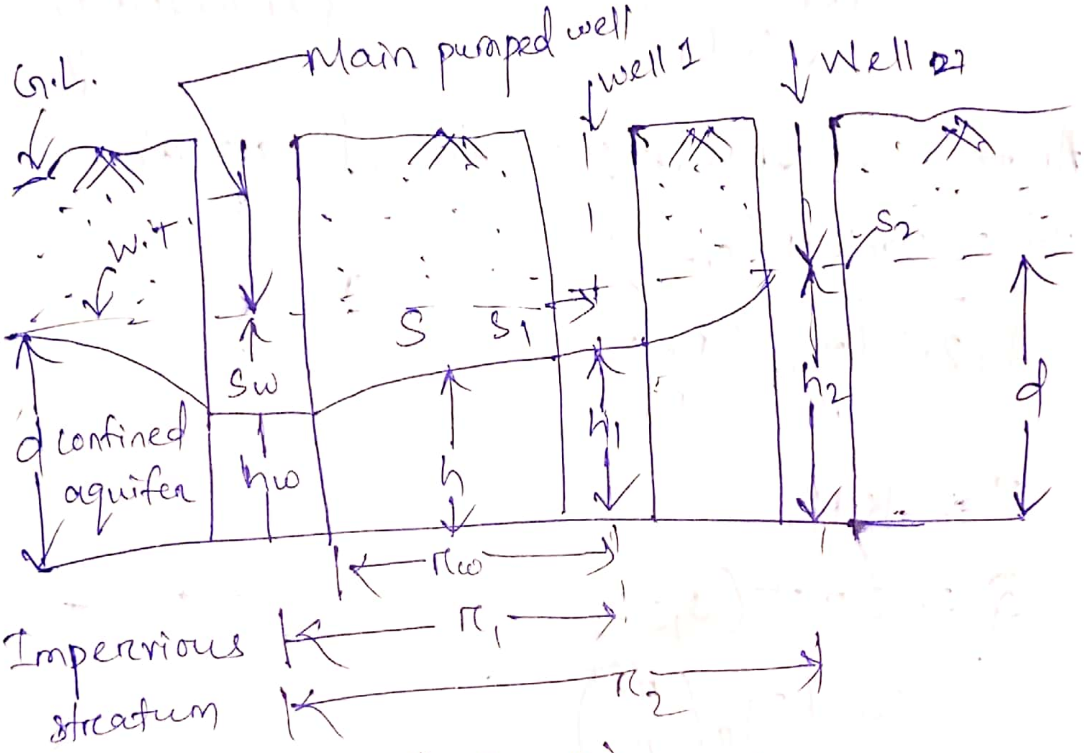
$$Q = C'.S$$

$$= \left(\frac{2.3}{T} \log_{10} \frac{S_1}{S_2}\right) A.S.$$

Yeilds of wells & tube wells by Thivm's equilibrium formulas.

① Thivm's formula for unconfined aquifer





$$Q = \frac{\pi K (h_2^2 - h_1^2)}{2.3 \log_{10}\left(\frac{r_2}{r_1}\right)} \quad \text{— ①}$$

$(h_2^2 - h_1^2) = (h_2 + h_1)(h_2 - h_1)$

$h_2 \simeq h_1$ (comparing to the large area)

$h_1 = h_2 = d$

$h_1 + h_2 = d + d = 2d$ and

$h_2 - h_1 = s_1 - s_2$

$h_2^2 - h_1^2 = 2d(s_1 - s_2)$

putting $h_2^2 - h_1^2$ value in eqn ①

$$Q = \frac{\pi k(2d(s_1 - s_2))}{2.3\log_{10}\left(\frac{R_2}{R_1}\right)}$$

$T = kd$ where T = coefficient of transmissibility

K = coefficient of permeability

$$Q = \frac{2\pi T(s_1 - s_2)}{2.3\log_{10}\left(\frac{R_2}{R_1}\right)}$$

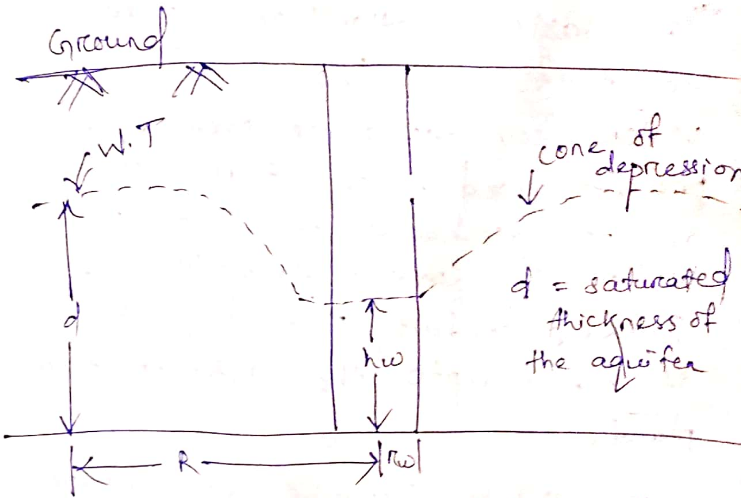
Artesian Rule: confined aquifer –

$$Q = \frac{2\pi kH(s_1 - s_2)}{2.3\log_{10}\left(\frac{r_2}{r_1}\right)}$$

$T = kH$

$$Q = \frac{2\pi T(s_1 - s_2)}{2.3\log_{10}\left(\frac{r_2}{r_1}\right)}$$

Dupuit's Formula for unconfined aquifer



d = saturated thickness of the aquifer

h_w = level of water in the well

R – Radius of influence

r_w – Radius of well.

$$R = \frac{\pi K(d^2 - h_w^2)}{2.3\log_{10}\left(\frac{R}{r_w}\right)}$$

For confined aquifer –

(In place of d, H)

$$Q = \frac{2\pi kH(D - h_w)}{2.3\log_{10}\left(\frac{R}{r_w}\right)}$$

D = Initial artesian pressure at the bottom of the aquifer

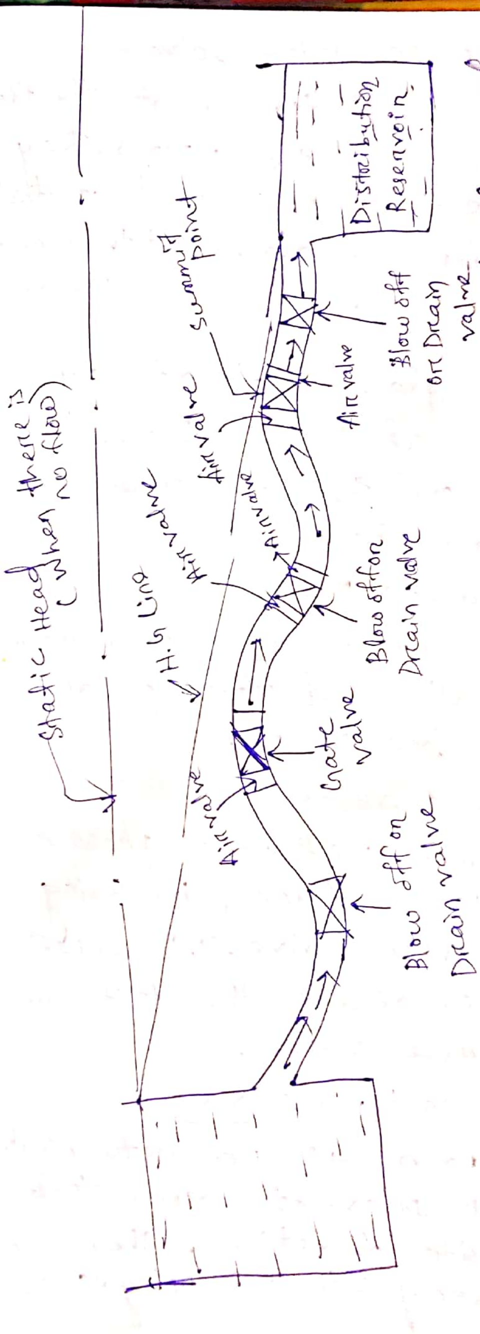
Scanned by CamScanner

Intakes for collecting surface water.

The basic function of intake structure is to help in safely withdraw water from the source over a predetermined range of poor levels and to discharge this water into the withdrawal conduit (Normally called Intake conduit) through which it flows upto the water treatment plant.

* Define Intake. Describe various types of intake with diagram.

* Describe Different types of pipe used in water supply project. along with their advantages & disadvantages.



Profile of the pressure pipe showing the locations of gates and valves.

Gate valve or sluice valve -

These are used to. regulate the flow of water through the pipes. They are located at an interval of 3 to 5 km. They are usually placed at the summit. (high point)

Air valve -

These are placed along the pipe at ~~the~~ summits at both side of the sluice valve and on the downstream side of all other sluice valve.

Blow off valve & Drain valve or scour valve -

To remove entire water from within a pipe, small gated off-takes are provided at low points.

Pressure relief valve -

Water hammer pressure in pressure pipe can be reduced by using pressure relief valve. The relief valve is provided in the offstream side of sluice valve.

Check valve or Reflux valve -

These are known as non-return valve because they prevent water to flow back in opposite direction. They are installed at the delivery site of pumping set.

Manholes -

These are provided at the suitable intervals along the pipe line to help laying and inspection and repairs of the pipe line at an interval of 300 - 600 m.

Ch-5

Water Quality Parameter

Characteristics of water -

① Physical
② Chemical
③ Biological

① Physical characteristics -

(a) Turbidity -

Large amount of suspended matter such as silt, clay or some other finely divided organic material which makes the water muddy, cloudy or Turbit is called Turbidity of water.

It is measured by turbidity rod or Turbidimeter

Unit → ppm or mg/l

Turbidimeter → Jackson turbidimeter unit - JTU
→ Bayli's turbidimeter

5-10 JTU is permissible limit
< 1 JTU is Depsirable

Colour -

Dissolved organic & Inorganic matter impacts colour to water and coloured soil also impact colour to soil.

Apparent colour → Suspended particles

True colour → Dissolved salts.

→ The colour of water is measured by comparing water sample with standard glass tubes known as Nessler's Tube containing solution of different colour intensity.

→ It's unit is TCU (True colour unit)

1TCU - By adding 1mg of platinum cobalt in 1l of distilled water we get 1TCU of colour in water.

→ By using Tintometer we measure colour of water.

→ For domestic used shouldn't be $\ngtr 20$ TCU.

For Desirable use limit is < 10 TCU.

Taste & Odour -

It is due to dissolved organic matter and inorganic salts or dissolved gases.

It is expressed in threshold odour no.

$$1\,TON = \frac{A+B}{A} = \frac{\text{Diluted sample}}{\text{Undiluted sample}}$$

where A = water sample in ml.

B = Distilled water in ml.

For domestic use TON shouldn't be $\ngtr 3$.

For Desirable use TON is 1.

Temperature.

Desirable - 10°C

$T \ngtr 25°C$.

Specific conductivity of water -

The total amount of dissolved salts present in water estimated by specific conductivity of water It is measured by portable Dionic water tester. Its unit is micromho/cm at 25°C.

Chemical characteristics -

① Total solids :-

(a) Suspended solids.

(b) Dissolved solids.

Total solid = Dissolved solid + suspended solid.

Permissible amount of solids in water is 500ppm.

② PH of water -

It is the logarithm of reciprocal of hydrogen ion concentration present in water.

$$PH = \log_{10}\left(\frac{1}{H^+}\right)$$

It is an indicator of acidity or alkalinity of water.

PH ↑ → less H^+ → Alkaline solution

PH ↓ → more H^+ → Acidic solution

$$H_2O \rightleftharpoons H^+ + OH^-$$

$$[H^+][OH^-] = 10^{-14} \text{ moles/l}$$

In Neutral water

$$[H^+] = [OH^-] = \sqrt{10^{-14}} = 10^{-7} \text{ moles/l}$$

$$PH = \log_{10}\left(\frac{1}{H^+}\right) = \log_{10}\frac{1}{10^{-7}} = 7$$

* $H_2O \rightleftharpoons H^+ + OH^-$

$NaOH \rightleftharpoons Na^+ + OH^-$

OH^- ion increases

H^+ ion remain same

$[H^+]$ decreases,

PH value increases.

* $H_2O \rightleftharpoons H^+ + OH^-$ H^+ ion increases.

$HCl \rightleftharpoons H^+ + Cl^-$ $[H^+]$ increases

PH value decreases,

* When PH < 7 → Acidic

Max^m acidic value is 0.

When PH > 7 → Alkaline

Max^m Alkalinity value is 14.

* Alkalinity cause by bicarbonate of calcium or Mg are called bicarbonate alkalinity.

* Alkalinity caused by Na, K, Ca, Mg are called carbonate alkalinity.

* Alkalinity caused by hydroxides of Na, K, Ca, Mg are known as hydroxides or custic alkalinity.

* Acidity caused by minerals, acids; CO_2, sulphates of Fe & Al in water.

* PH is measured by potentiometer.

* Permissible limit of pH is 6.5 to 8.5 for domestic use.

Tuberculation -

It is the development of small mounds of corrosion products on the inside of iron pipes.

Acidic → Tuberculation and corrosion in pipe line

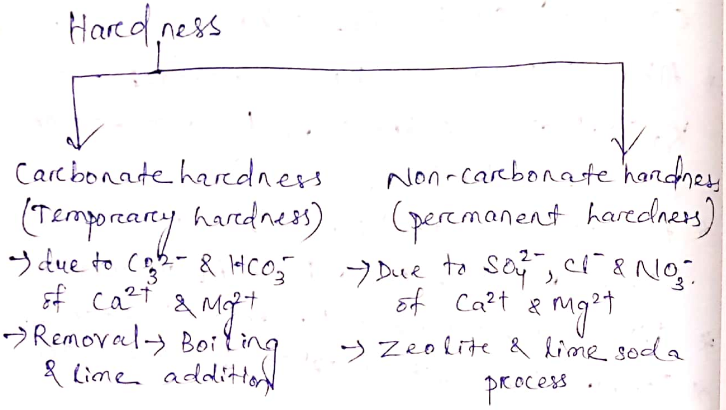
Alkaline → Incrustation and sediment deposite.

③ **Hardness** -

Haredness prevents the formation of sufficient lether or fom when mixed with soap. It is caused by calcium & Mg salt.

Demerit -

① Huge soap consumption.
② Scaling of boilers.
③ Corrosion & incrustation of pipe.
④ Makes food tasteless.



Hardness

Carbonate hardness (Temporary hardness)
→ due to CO_3^{2-} & HCO_3^- of Ca^{2+} & Mg^{2+}
→ Removal → Boiling & lime addition

Non-carbonate hardness (permanent hardness)
→ Due to SO_4^{2-}, Cl^- & NO_3^-. of Ca^{2+} & Mg^{2+}
→ Zeolite & lime soda process.

Total hardness -

It is defined as calcium carbonate equivalent of Ca & Mg ion present in water in mg/l.

→ Total haredness =

$$\left[(Cl^{2+} \text{ in mg/l}) \times \frac{\text{combining wt of } CaCO_3}{\text{Combining wt of } Ca^{2+}}\right] + \left[Mg^{2+} \text{ in mg/l} \times \frac{\text{combining wt of } CaCO_3}{\text{combining wt of } Mg^{2+}}\right]$$

combining wt. of $CaCO_3 = 50$
$Ca^{2+} = 20$
$Mg^{2+} = 12$

Carbonate hardness -

It is equal to total hardness or alkalinity which ever is less.

Non-carbonate hardness -

It is equal to total hardness - Alkalinity ~~to~~ If alkalinity is equal to or greater than total hardness, there is no non-carbonate hardness.

Example -

Carbonate & Noncarbonate hardness of a water having total alkalinity of 200 mg/l as $CaCO_3$ and 120 mg/l of Ca^{2+} and 60 mg/l as Mg^{2+} is 60 mg/l.

$$\left(120 \times \frac{50}{20}\right) + \left(60 \times \frac{50}{12}\right)$$

$= 300 + 250$
$= 550$ mg/l as $CaCO_3$.

Carbonate hardness is 200 mg/l because $200 < 550$.

Non carbonate hardness is $550 - 200 = 350$ mg/l as $CaCO_3$.

→ Water of hardness ≮75 ppm is known as soft water.
→ Water with hardness ≯200 ppm is known as hard water.
→ In betn 75 and 200 ppm the water is moderately hard.

→ For boiler field & cloth washing the hardness should be $\ngtr 75$ ppm.

→ For domestic water supply hardness should be in betn 75 to 115 ppm.

Q) During a recuparation test the water level in an open well was depressed by pumping by 2.5m and is recuparated by an amount of 1.6m in 70 min.

① Determine the yield of well of 3m dia under a depression head of 3.5m.

② Also determine the dia. of the well to yield 10m/s under a depression head of 2.5 m.

Ans - $S_1 = 2.5$ m

$S_2 = 2.5 - 1.6 = 0.9$

$T = 70 \text{ min} = \frac{70}{60} = 1.17$ hr.

$$\frac{C'}{A} = \frac{2.3}{T} \log_{10}\left(\frac{S_1}{S_2}\right)$$

$$= \frac{2.3}{1.17} \log_{10}\left(\frac{2.5}{0.9}\right)$$

$$= 0.875$$

If $d = 3$m & $S = 3.5$

then $A = \frac{\pi}{4} d^2 = \frac{\pi}{4} \times 3^2 = 7.068$

Then $Q = \frac{C'}{A} * A * S = 0.875 \times 7.068 \times 3.5$

$= 21.57$ m³/h

$1 m^3 = 1000 l$.

$1 l = 10^{-3} m^3$

$10 l/s = 10 \times 10^{-3} = 10^{-2} m^3$

$1 hr = 3600 s$.

$1 s = \frac{1}{3600}$ hr.

$10 l/s = 10^{-2} \times 3600$ m³/hr

$= 36$ m³/hr

$36 = 0.875 \times A \times 2.5$

$$A = \frac{36}{0.875 \times 2.5} = 16.457$$

$A = \frac{\pi}{4} d^2 = 16.457$

$$d^2 = \frac{16.457}{0.785} = 20.96$$

$d = \sqrt{20.96} = 4.6$

Q) A pumping test was made in a medium sand and gravel to a depth of 15 m. where a bed of clay was encountered. The normal ground water level was hand surface. Observation holes were located at distances of 3m and 7.5m from the pumping well at a discharge of 3.6 l/s from the pumping well, a steady state was attend in about 24 hr. the drawdown at 3m was 1.65m and at 7.5m was 0.36 m. Compute the coefficient of permeability of soil.

Ans- $Q = 3.6\ l/s$

$d = 15m$

$r_1 = 3m$

$r_2 = 7.5\ m$

$S_1 = 1.65\ m$

$S_2 = 0.36\ m$

$$Q = \frac{3.6}{1000}\ m^3/s$$

$h_1 = 15 - 1.65 = 13.35$

$h_2 = 15 - 0.36 = 14.64$

$$Q = \frac{\pi k (h_2^2 - h_1^2)}{2.3 \log_{10}\left(\frac{r_2}{r_1}\right)}$$

$$\frac{3.6}{1000} = \frac{\pi k ((14.64)^2 - (13.35)^2)}{2.3 \log_{10}\left(\frac{7.5}{3}\right)}$$

$$= \frac{\pi k (36.107)}{2.3 \times 0.398}$$

$$\frac{3.6}{1000} = 123.917\ k$$

$$k = \frac{3.6}{1000 \times 123.917} = 2.9 \times 10^{-5}\ m/s$$

$$= 2.9 \times 10^{-5} \times 100$$

$$= 2.9 \times 10^{-3}\ cm/s$$

* $\boxed{1\ \text{Gallon} = 4.55\ l}$

Q) A 30cm dia well penetreates 25m below static water table. After 24hrs of pumping at the rate of 5400 l/min, the water level in a test well at 90m is lowered by 0.53 m and in a well 30m away the draw down is 1.11m.

① What is the transmissibility of the aquifer.

② Also determine the draw down in the main well

Ans. $Q = 5400\ l/min$

$$= \frac{5400}{1000}\ m^3/min = 0.09\ m^3/s$$

$d = 25\ m$

$S_2 = 0.53\ m$

$r_2 = 90m$

$h_2 = 25 - 0.53 = 24.47\ m$

$r_1 = 30\ m$

$S_1 = 1.11\ m$

$h_1 = 25 - 1.11 = 23.89\ m$

$$Q = \frac{\pi k (h_2^2 - h_1^2)}{2.3 \log_{10}\left(\frac{r_2}{r_1}\right)} = \frac{\pi k ((24.47)^2 - (23.89)^2)}{2.3 \log_{10}\left(\frac{90}{30}\right)}$$

$$0.09 = \frac{88.118\ k}{2.3 \times 0.477}$$

$\Rightarrow k = 1.12 \times 10^{-3}\ m/s$

$T = kd$

$= 1.12 \times 10^{-3} \times 25 = 0.028\ m^2/s$

⑪ $$Q = \frac{\pi k (h_1^2 - h_w^2)}{2.3 \log_{10}\left(\frac{r_1}{r_w}\right)}$$

$$r_w = \frac{30}{2} cm = 15 cm = 0.15 m$$

$$0.09 = \frac{\pi \times 1.12\times10^{-3} \times ((23.89)^2 - h_w^2)}{2.3 \log_{10}\left(\frac{30}{0.15}\right)}$$

$$0.09 = \frac{3.518\times10^{-3} \times 570.73 - 3.518\times10^{-3} h_w^2}{2.3 \times 2.3}$$

$$0.09 = \frac{2 - 3.518\times10^{-3} h_w^2}{5.29}$$

$$0.09 \times 5.29 = 2 - 3.518\times10^{-3} h_w^2$$

$$0.4761 - 2 = -3.518\times10^{-3} h_w^2$$

$$h_w^2 = \frac{\cancel{-}1.5239}{\cancel{-}3.518\times10^{-3}}$$

$$h_w^2 = +433.172$$

$$h_w = \sqrt{433.172}$$

$$= 20.81$$

Q1) Describe various chemical & physical characteristics of drinking water.

2) Describe infiltration well and infiltration gallery with diagram.

3) Describe various types of aquifer with diagram.

Chloride Contained

→ Chloride present in water in the form of salt (NaCl).

→ It is due to pollution of water due to seewage, industrial and human waste.

→ Chloride contained is measured by titrating the water with standard silver nitrate soln ($AgNO_3$) using potassium chromite as indicator.

→ Its limit for drinking water should not exceed 250 ppm.

Nitrogen content -

→ Present of Nitrogen indicates presence of organic matter.

→ Nitrogen present in following forms.

① Freed Amonia.
② Organic Amonia (Albumeinoid)
③ Nitrite (NO_2^{2-})
④ Nitrate (NO^{3-})

→ Free Amonia indicates 1st stage of decomposition of organic matter. (Recent pollution)

→ Organic Amonia represents quantity of nitrogen present in water before decomposition of organic matter started.

→ Nitrites indicates presence of ~~hardly~~ Partly decomposed organic matter.

→ Nitrate indicates presence of fully oxidised organic matter. (old pollution).

→ Free Amonia shouldn't be ≯ 0.15 mg/l in drinking water.
It is measured by boiling the water and measure liberated Amonia by distillation process.

→ Organic Amonia is measured by boiling a boiled sample with a strong oxidising agent ($KMnO_4$).

→ Combination of free ~~Amonia &~~ Nitrogen & Organic Nitrogen is called ~~Kedal~~ Kjedahl nitrogen.

→ The kjedahl nitrogen is obtained by adding $KMnO_4$ to unboiled cold water and then the sample is boiled, then the liberated nitrogen will include free Nitrogen & Organic nitrogen.

→ Drinking water shouldn't contain more than 0.3 mg/l of organic Nitrogen.

→ Partly oxidised organic matter (Nitrite) is very dangereous and its limit in drinking water is 0.

→ Nitrite has high affinity to hemeoglobin than that of oxygen. so it replaces oxygen and is very dangereous.

→ Fully oxidised organic matter (Nitreate) is not harmful but if present in large quantity will affect infants and cause a disease called Mathemoglobinemia or Blue Baby disease.
Its permissible limit in drinking water is 45 mg/l.

→ **Fe & Mn contained** :-

→ It cause hardness, discoloration to gloreous and incrustation in pipe.

$Fe \ngtr 0.3\ mg/l$

$Mn \ngtr 0.05\ mg/l$

Cu contained -

→ High quantity of Cu affect hum lungs and other respirator organs.

→ Sulphate concentration in $CuSO_4$ shouldn't be ≯ 250 mg/l and in Cu is 0.05 – 1.5 mg/l.

Fluoride contained

→ If the Fluoride is < 1 mg/l, then it will cause dental cavities.

→ If it is > 1.5 mg/l, then it will cause fluorosis (spotting & discolourati of teeth)

→ If it is > 5 mg/l, then deformation of bone (bone fluorosis).

→ Phosphorous contained -

→ It is non toxic and causes no health hazard due to presence of higher phosphorous contain the aquatic plants will grow at a faster rate and will cause future pollution and will cause obstraction in chemical coagulation process.

Various Toxic metals -

Arsenic (As)
Barium (Ba)
Cadmium (Cd)
Chromium (Cr)
Lead (pb)
Mercury (Hg)
Silver (Ag)

Some toxic materials which shouldn't be present in drinking water.

Cyanide ≯ 0.2 mg/l
phenolic ≯ 0.001 mg/l

Dissolved Gases -

N, CH_4, H_2S, CO_2, O_2,

→ CH_4 will cause explosive tendency. (It will suddenly catches fire)

→ H_2S will give bad taste & odour.

→ CO_2 indicate biological activity, imparts bad taste & odour and cause corrosion on the pipe line.

→ O_2: Minimum ~~O2~~ dissolved O_2 in aquatic life should be 4 mg/l present in water,

With increase in temp. O_2 contained will decrease,

At 20°C dissolved O_2 is 9.2 mg/l

If it is <4 mg/l then the aquatic animal will die.

BOD - (Biochemical Oxygen Demand)

Amount of oxygen required in the decomposition of waste & organic matter by aerobic bacteria until oxidation gets completed is known as BOD.

→ BOD of water during 1st 5 days at 20°C is known as standared demand.

→ BOD_5 is determined by mixing or diluting known volume of raw water sample with known volume of pure water sample, saturated with a known quantity of dissolved oxygen in mg/l. and incubating it for 5 days at 20°C.

→ Difference betn original oxygen contained and the residual oxygen contained will give oxygen consume by water sample in 5 days.

$$BOD_5 = \text{loss of oxygen in mg/l} \times \text{Dillution factor}$$

→ BOD of drinking water should be equal to 0.

Purification of water supplies:-

Methods of purification of water supplies

① Screening
② Plain sedimentation
③ Sedimentation with coagulation
④ Filtration
⑤ Disinfection
⑥ Aeration
⑦ Softening
⑧ Miscellaneous treatments.

Coarse & fine sereans -

Coarse and fine sereans are provided in front of pumps & intake to excluded debris, dead animal tree trundes, leaves branches etc.

→ These are provided in the form of fine wirness for propeoated metal opening or coarse screans.

→ Various suspended impurity whose specific gravity 'G' greater than 1 can be remove by plain sedimentation.

→ The basin in which flow of water is retarded is called settling tank or Sedimentation tank or clearifier.

→ The theoretical avg. time ~~ste~~ for which the water is detention period is called as Detention period.

→ Factor on which setteling velocity dep

Viscosity - decrease

Sattlement - increase

① Horizontal flow tank

② Vertical flow tank.

③ Sedimentation with coagulation -

Very fine floculated mud particles and colloidal matter are remove by this process. The very fine particle are -vely charged which are attracted & absorb in floc (gelatineous precipitated formed by adding coagulant with raw ~~matter~~ water)

Various chemical -

(i) Alum (Aluminium sulphate) ($Al_2(SO_4)_3 \cdot 18H_2O$)

→ It forms Aluminium hydroxide ($Al(OH)_3$) → Floc.

Dose → 5mg/l → clear water

85mg/l → highly turbid

(ii) Copperas (iron salt) → $FeSO_4 \cdot 7H_2O$

→ It forms ($Fe(OH)_3$) as floc

(iii) Chlorinated copperas

→ It forms $Fe(OH)_3$ as floc.

(iv) Sodium aluminate ($Na_2Al_2O_4$)

(4) Filtration :-

·To remove very fine suspended particle and bacteria, filtration is use. The process of passing water through beds of ganular material (sand) is known as filtration.

→ It helps in remove colour, odour, turbity & various pathogenic bacteria.

Theory of filtration -

These are four process by which water is purified in filtration.

(1) Mechanical straining -

When particle size is greater than size of voids in sand layed of filter then these are remove also the flocs which remain on the top of the filter bed also help in filtering the particle.

(ii) Flocculation and sedimentation -

The voids passes ~~a~~ at lie small coagulation sedimentation which filter the colloidal method of size 10^{-3} to 10^{-6} mm.

Scanned by CamScanner

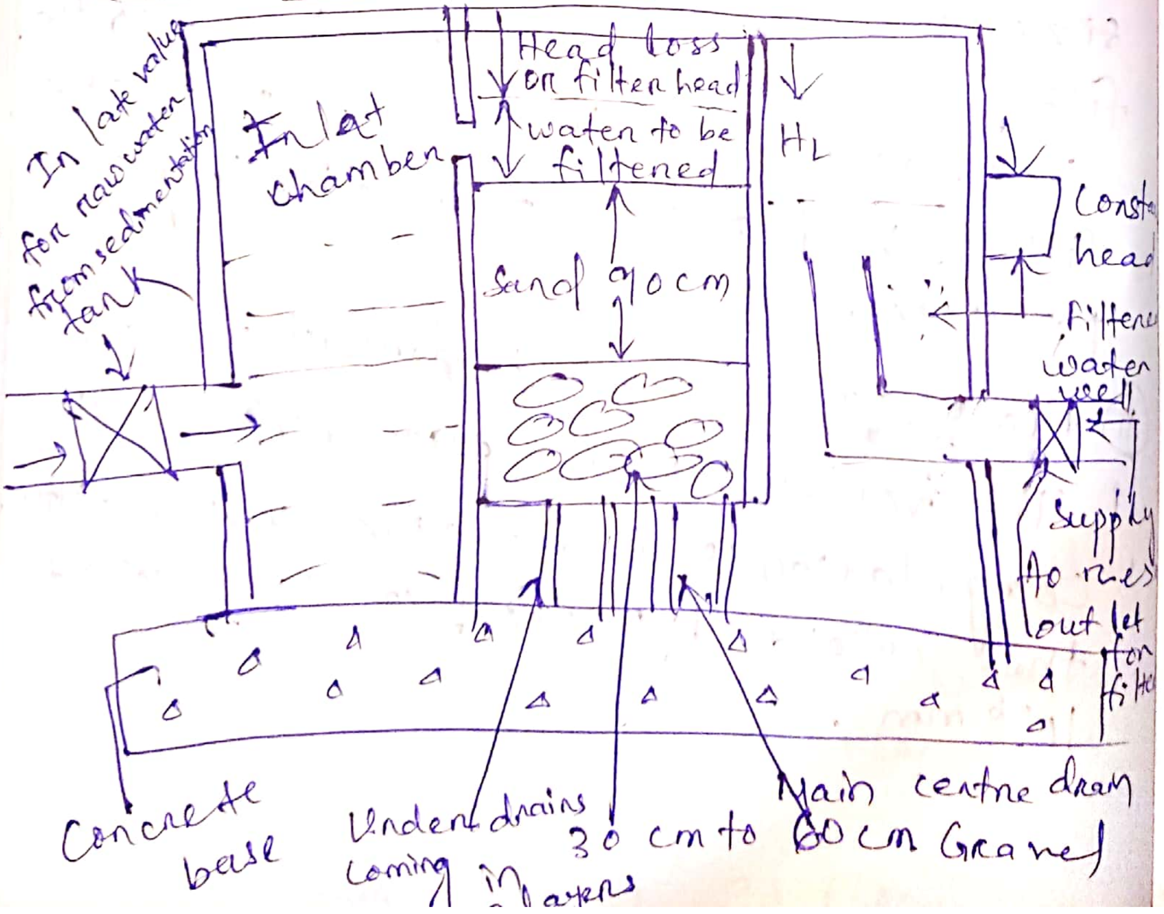
(iii) Biological metabolism -

The micro organism & bacteria present in the voids of filter antilize organic impurity and convert them harmless compound by biological metabolism. The layer of these compound will help in absorbing & straining out impurity.

(iv) Electrolytic charges -

Sand particles and impurity carrying electrical charge of opposite nature when there in contact to each other, so this opposite charge will neutralize of water & purified ~~ok~~ it.

Slow sand filter -



The filter material used in fiter have sand & gravel.

→ The sand should be obtained from Quartzite rock & it should be free from that & other impurity. It should be uniform size of nature hard & resistance and shouldn't loose more than 5% of weight after placing in hydrochloric acid for 24 hour.

→ The gravel which are use below the sand layer should be free from impurity, rounded in shape & having density 1600 kg/m.

→ The filter is of 3 type.

(i) slow sand filter.
(ii) Rapid gravity filter.
(iii) Pressure filter.

① Slow sand filter -

ⓐ Construction & various part :-

① Encloser tanks :-

Open water tied rectangular tank of masonry or concrete with bed slope 1 in 100 towards the central drain and is having depth 2.5 to 3.5 m. The tank has planned area of 100 to 2000 sqm.

② Filter media -

It consist of sand layer of depth 90 to 110 cm depth over gravel lay The sand has affective size D_{10} = 0.2 to 0.4mm and coefficient of uniformity (Cu) is 1.8 to 2.5 or 3mm. The top 15cm layer of sand ~~and~~ are finer and the size of sand gradually increases towards bottom.

③ Base material -

The gravel layer or thickness 30 to 75 cm and used to support the sand layer. their are 3 to 4 layers of gravel each of 15 to 20cm depth. The finest gravel having size 3 to 6 mm. Intermedium gravel layer is having size of 20 to 40 mm and 6 to 20 mm, the bottom layer is having gravel size of 40 to 65 mm.

④ Under drainage system -

The gravel support is laid on the top of Under drainage system. It consist central drain and lateral drain. The lateral drain consist of porous open jointed by at 3 to 5m. appart. The laterals collect the filter water and discharge into main drain.

Operation & cleaning -

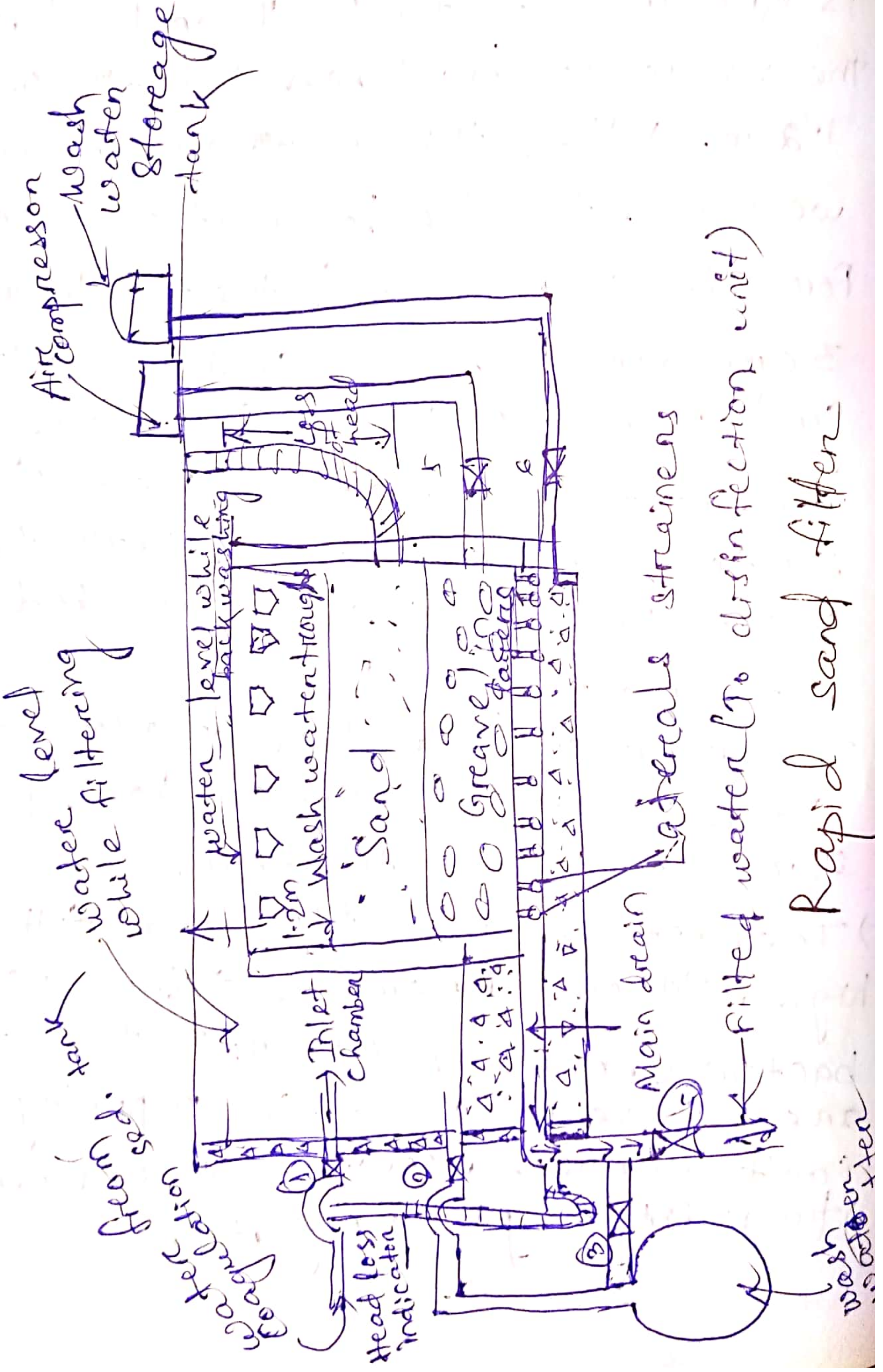
the water entering the filter shouldn't be treated by coagulants because the flocs generated will affect the filtering process. the loss of head due to resistance offered by sand particle is known as filter head or head loss. The value of head loss is max^m 0.7 to 1.2 m. When this max^m value reaches we clean the top layer of the sand. For cleaning remove the top 1.5 m to 3 cm sand layer and wash with good water. After cleaning. the affluent should n't be used for 24 to 36 hr. The interval bet^n two successive cleaning of filter bed is 1 to 3 month.

→ The rate of filtration of floc and filter is 100 to 200 l. per hour per sq m. area of filter bed.

→ The efficiency of floc and filter is high. It can remove 98% to 99% bacteria, removes odour test which are caused by organic impurity. It can't remove colour. It can remove turbidity upto 5 mg/ltr.

Use -

It is suitable for village supply, smaller plant low colour, turbidity & low bacteria content. It requires large surface area and large volume of filter material.



Rapid sand filter

Components –

Encloser tank –

It is an open water tied rectangular tank made of RCC or masonry.

Depth → 2.5 to 3.5m.
Area of unit = 10 to 80 m^2/unit
min^m 2 units.

Filter media –

Sand layer is of 60 to 90 cm depth over gravel support.

D_{10} = 0.35 to 0.55
C_u = 1.3 to 1.7

Base material –

Gravel – 60 to 90 cm depth.
It is placed in 5 to 6 layer. with increasing gravel size towards the bottom.

Under drainage system –

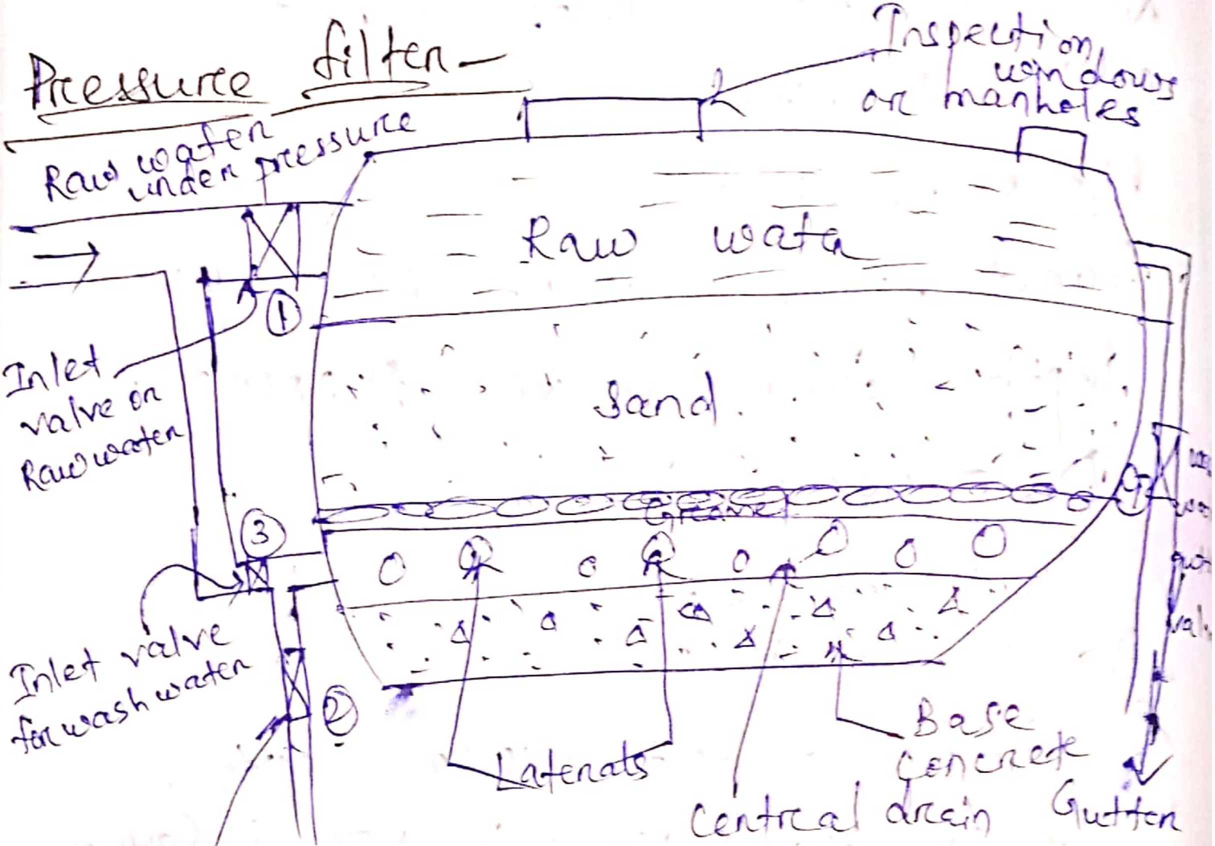
These are provided to receive and collect the filtrate water and to allow back washing for cleaning the filter. at the rate of 300 – 900 l/min/m^2 of filter area.

① Manifalt & Lateral system
② corporated pipe system.

Working principle -

(in) water - influent
(out) water - effluent

Pressure filter -



(Horizontal pressure filter)

Swimming pool
play stations
small colonies.

These are small rapid gravity filters placed in closed vessel through which water is passed under pressure.

Dia = 1.5 to 3m.

height or length - 3.3 to 8 m.

Difference between slow sand & rapid gravity filter -

Sl No.	Item	Slow sand	Rapid sand.
1	Pre-treatment requirement	Effluent from plain sedimentation tank or raw water without any treatment are fed in to them.	Coagulation, flocculation & sedimentation are done before filtration
2	Size of each unit.	Large size (100-2000 sqm)	Small size (10-80 sq m)
3	Rate of filtration	Small (100-200 l/hr/m² of filter area)	Large (3000-6000 l/hr/m² of filter area)
4	Economic	high initial cost but low cost of operation & maintenance	Low initial cost but high cost of operation & maintenance but overally it is cheaper and economical.
5	Efficiency	Very efficient in removing bacteria (98%-99%) But less efficient in removing colour. This filter is unsuitable for turbidity >50mg/l.	Less efficient in removing bacteria (80-90%) But very efficient in removing colour. They can handle very turbit waters.

6 Suitability–	Adopted for treating smaller village supplier on industrial supply, especially at uten places. These are now become opsolete.	They are widely used and universally adopted for treating public supply at all major cities and towns.
7 Mathod of cleaning	Scrapping and removing the top 1.5 – 3 cm thick layer and washing by water jets. It is very laborious method.	Agetating the sand grains and back washing with or without compressed air. It is shorted & easy method.
8 Quantity of wash water required.	Very small. (0.2% – 0.6%) of total filter.	Large amount (1 – 5)% of filtrate water
9 Period of cleaning	It is cleaned at an interval of 1 to 3 months.	It is cleaned frequently at an interval of 1 to 3 days.

Disinfection & or Sterilization :-

The various bacterias which are present in water must be killed to make the water safe for drinking.

The chemicals which are used to kill the bacterias are known as disinfectant and the process is called disinfection or sterilization.

Cl is the best disinfectant.

✓ **Minor methods of disinfection —**

- (i) Boiling
- (ii) Treatment with excess lime
- (iii) Treatment with ozone.
- (iv) Treatment with I & Br
- (v) Treatment with Ultra violet rays
- (vi) Treatment with $KMnO_4$
- (vii) Treatment with Ag^+ (Electro katalyne process)

(ii) **With excess lime -**

14 to 43 ppm → 99.3 to 100 % bacterias killed

pH > 9.5 → 99.9 to 100%

Recarbonation → remove excess lime.

(iii) **with ozone :-**

Blue gas with pungent odour.

$$3O_2 \xrightarrow[\text{high electric arc. voltage}]{\text{under}} 2O_3$$

$$O_3 \rightarrow O_2 + O$$

(Nascent oxygen)

2 to 3 ppm O_3 → residual ozone of 0.
at 10 min contact period

Ⓘⓥ **with I & Br –**

8 ppm at 5 min contact period.
used only for Army troop, swimming pool, private plant, etc.

ⓥ **with UV rays –**

UV rays are invisible rays with wave length 1000 – 4000 mμ.
These are found in sunlight
UV rays are generated artificially by passing electric current through Hg enclosed in quartz bulbs.
The UV ray ~~permit~~ passes up to 10cm depth of water of water. if the turbidity is low.

Advantage

It will not produce bad taste or odour and colour to the water.

Disadvantage

It is very costly.
It is not used for public ~~[illegible]~~ use
It is used ~~[illegible]~~ in hospital, dispensary, swimming pool.

(VI) with $KMnO_4$ -

It is used to disinfect wells water,
It is used in rural areas.

0.05 to 0.10 mg/l is.
After 48 hrs of applying this $KMnO_4$ the water is used.

Normal dose → 1 to 2 mg/l
→ 4 to 6 hrs.
98% bacteria but 100% cholera carrying bacteria.

(VII) with Ag^+ -
(I) Two cathods are there.
(II) 1.54 DC current supplied in the water.

Ag^+ → 0.05 to 0.1 mg/l → 15 min to 3 hr

Advantages -

(I) Remove H_2S & organic matter.
(II) It doesn't produced bad taste, odour & colour to the water.

Disadvantages -

(I) It is very costly.

Chlorination -

→ It is universally used in public water supply. It is cheep, reliable, easy to handle, easily measurable, provide residual disinfecting ~~effe~~ affect to the water.

→ measure disadvantages is It will impart bitter & bad taste to water.

→

$$Cl_2 + H_2O \xrightarrow{PH > 5} HOCl + HCl$$

(Hypochlorous acid)
unstable.

$$HOCl \underset{PH<7}{\overset{PH>8}{\rightleftharpoons}} H^+ + OCl^-$$

(Hypochlorite ion)

$[Cl_2, HOCl. \& OCl^-]$ are called Free chlorine.

HOCl is 80 times more powerful than OCl^- to kill the bacteria..

~~PH value is 5~~

$5 < PH < 7$ for HOCl.

- The generated HOCl will immediately react with NH_3 to form chloramine compound

II

chloramine compounds is also a disinfecting chemical. But it will act after some duration of time not immediately.

→ It will act to kill S^-, Fe^{2+}, Mn^{2+} & NO_2^-

→ After all the above reaction, Cl_2 will act in water.

→ Cl_2 residual should be 0.2 mg/l, 10 min

✓ Types of chlorination –

- (i) Plain chlorination
- (ii) Pre chlorination
- (iii) Post chlorination
- (iv) Double chlorination
- (v) Break point chlorination
- (vi) Super chlorination
- (vii) Dechlorination

(i) Plain chlorination –

Dose – 0.5 mg/l or more.

This indicates only chlorine treatment and no other treatment to raw water.

This helps in removing bacteria, organic matter & colour from raw water.

This is used for relatively clear water. (Lake or reservoir water)

(i) Pre chlorination –

The process of applying chlorine to water before filtration or befor sedimentation – coagulation. It improve coagulation & reduce the load on filters.

Dose – 0.1 to 0.5 mg/l.

Max^m upto 5 to 10 mg/l.

It is always ~~at~~ followed by post chlorination.

(iii) Post chlorination –

It is simply called chlorination. In this process cl_2 is applied finally at the end of ~~when~~ all treatment processes are completed. It is done after filtration proces Dose of chlorine is such as the lead 0.1 to 0.2 mg/l of residual Chlorine. After a contact period of 20 mins.

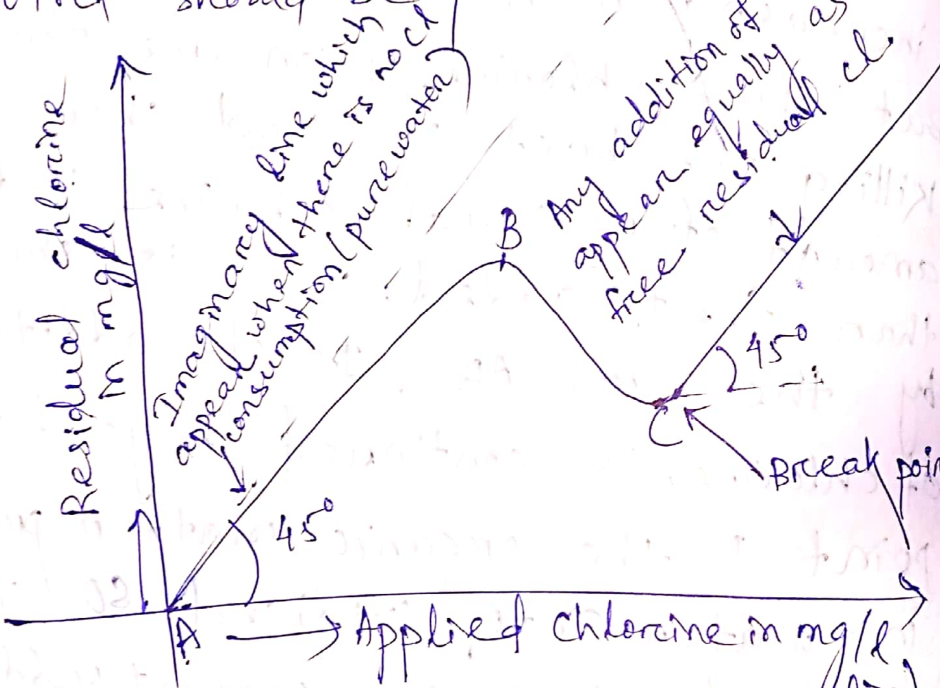
(iv) Double chlorination –

It indicates the water has been Chlorinated twice. (Pre + post chlorinati

(v) Break point chlorination –

It is the term which gives us the idea of the extent of chlorine added to water. It represents the dose of ~~chlor~~ chlorination beyond which any further addition of chlorine will remain as free residual chlorine.

If chlorine is slowly added to water and residual is tasted, it is found that residual will born increasing with addition of chlorine. But some chlorine is consume for killing the bacteria and show the amount of residual chlorine is less than that added. which is shown by the curve AB. If the addition of chlorine is continued beyond the point B the organic matter present in water gets oxidised. so the residual chlorine content suddenly falls down as showned by curve BC. The curve C is the point beyond which any further addition of chlorine will appear equally as ~~residual~~ free chlorine. The point C is called break point as any chlorine that is added to water beyond this points breaks through the water and appear as residual chlorine. Addition of chlorine beyond break point is called break point chlorination. At point B when oxida of organic matter starts a bad smell and taste generally appears, which disappears at the break point C. ~~Clk~~ The residual Cl_2 should be 0.2 to 0.3mg/l after break point should be present.



(Break point chlorination)

(vi) Super chlorination

Super chlorination is a term which indicates the addition of excessive amount of chlorine (i.e. 5 to 15 mg/l) to the water. This may be required in some special cases of highly polluted wat or during epidemics of water borne dise It may be used when there is a reason believe that the water contains cysts of histolytica (i.e. the organism which causes amoebic dysentery.

The huge quantity of chlorine which is added in superchlorination is such as to give about 1 to 2 mg/l of residue beyond the break point in the treated water. Sometimes, even higher doses may be used and the resultant water is dechlorinated after the end of the desired contact period, by using dechlorinating agents such as sodium thiosulphate, activated carbon, sulphur dioxide, etc. This ensures the removal of bad tastes and odours caused by the presence of excess chlorine, but may render the water free from chlorine and susceptible to recontamination. Hence, in such cases, it is desireable to again chlorinate the water by a dose of about 0.1 to 0.2 mg/l.

(VII) Dechlorination:

As indicated above, the dechlorination means removing the chlorine from water. This is generally required when superchlorination has been practised. The dechlorination process may either be carried out to such an extent that sufficient residual chlorine (0.1 to 0.2 mg/l) do remains in water after dechlorination; or otherwise, if full chlorine has been removed, additional chlorine will generally be added to maintain such residues.

The dechlorination may be carried out be adding certain chemicals to water or by simply aerating the water.

These chemicals are called dechlorinati agents.

The common dechlorinating agents are Sulphur dioxide gas ($SO_2\uparrow$), Activated carbon, Sodium thiosulphate ($Na_2S_2O_3$), Sodium metabisulphate ($Na_2S_2O_5$), Sodium Sulphite (Na_2SO_3), Sodium bisulphite (NaH and Ammonia as NH_4OH.

SO_2 gas may be applied to water somewhat in the same manner as chlorine with a minimum contact period of about 10 to 15 minutes, with a dose of about 0.3 to 0.6 ppm, depending upon the excess chlorine present in water. The required SO_2 to excess Chlorine ratio is 1.12:1 with an additional 25% of SO_2 over this theoretical requirement. Sulphites are granular solids, which may be added to water by dry or solution feed methods. Although Sodium sulphite is cheaper in per kg cost, yet sodium thiosulphate proves overall cheaper, since lesser quantity of sodium thiosulphate is required to obtain the same results.

Ammonia may also be useful and economical dechlorinator, because of its reaction with chlorine to form chloramines.

→

2nd process

By addition of lime-

$MgCO_3 + Ca(OH)_2 \rightarrow Mg(OH)_2\downarrow + CaCO_3\downarrow$

Soluble — Hydrated lime — (Insoluble ppt)

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

$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3\downarrow + 2H_2O$

✓ To remove permanent hardness -

There are 3 process

① Lime soda process

(II) Base exchange process or zeolite process.

(III) De-milerisation process.

① Lime soda process -

In this process lime & sodaash (Na_2CO_3) are added to hard water which create with calcium & magnesium salt to form insoluble precipitate of calcium & magnesium.

$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3\downarrow + 2H_2O$

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

$MgCO_3 + Ca(OH)_2 \rightarrow Mg(OH)_2\downarrow + CaCO_3$

$MgCl_2 + Ca(OH)_2 \rightarrow Mg(OH)_2\downarrow + CaCl_2$

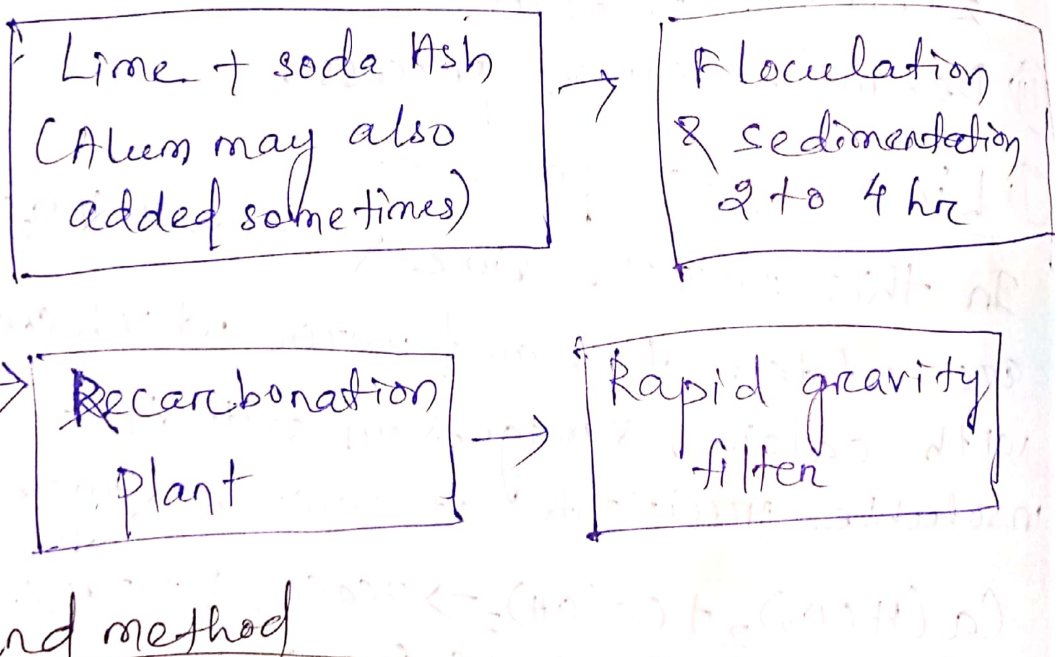
$MgSO_4 + Ca(OH)_2 \rightarrow Mg(OH)_2 \downarrow + CaSO_4$

$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 \downarrow + H_2O$.

$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 \downarrow + 2NaCl$

$CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 \downarrow + Na_2SO_4$

→ Some of the finely divide ppt of Cl & $Mg(OH)_2$ can't be easily filter so by mixing carbon dioxide gas these ppt are converted into soluble calcium & Magnesium, bicarbonate, these process is called recarbonation process.



2nd method

Zeolite/base exchange/cation exchange process—

zeolite is a natural green colour salt or clay hydrated silicate of sodium & Aluminium.

$Na_2O \cdot Al_2O_3 \cdot xSiO_2 \cdot yH_2O$

Artificially zeolite can be produce & is known as synthetic ~~reason~~ resin. which is white in colour & it is also known as permutit.

$$NO_2Z + \begin{matrix} Ca \\ Mg \end{matrix} \left\{ \begin{matrix} (HCO_3)_2 \\ SO_4 \\ Cl_2 \end{matrix} \right. \rightarrow NO_2 \left\{ \begin{matrix} (HCO_3)_2 \\ SO_4 \\ Cl_2 \end{matrix} \right. + \left. \begin{matrix} Ca \\ Mg \end{matrix} \right\} Z$$

Sodium zeolite on active zeolite

Ca. or Mg salt

Sodium salt

using zeolite

$$\left. \begin{matrix} Ca \\ Mg \end{matrix} \right\} Z + 2NaCl \rightarrow Na_2Z + \left. \begin{matrix} Ca \\ Mg \end{matrix} \right\} Cl_2$$

Demineralisation process –

Removing mineral by passing the water through a bed of cation exchange regin & through a bed of Anion exchange regin.

$$\text{Cation} \left\{ \begin{matrix} Ca(HCO_3)_2 + H_2R \rightarrow CaR + 2HCl \\ MgSO_4 + H_2R \rightarrow MgR + H_2SO_4 \end{matrix} \right.$$

$$\text{Anion} \left\{ \begin{matrix} ROH + HCl \rightarrow RCl + HON \\ 2ROH + H_2SO_4 \rightarrow R_2SO_4 + 2HOH \end{matrix} \right.$$

Miscallaneous treatment –

① Aeration

② Activated carbon

③ With $CuSO_4$

④ With oxidising agent

⑤ Removal of salt & dissolved solid

⑥ Removal of Fe & Mn

Water softening -

The reduction ~~of~~ or removal of hardness from water is called water softening.

Temporary or carbonate hardness are caused by carbonate & bicarbonate of Calcium & magnesium. These are remove by boiling or by adding lime.

The permanent of non-carbonate are called as sulphate, chloride, nitrate of Calcium & Magnesim. These are removed by various

permissible hardness limit is 75 to 115 mg/l : 1° of hardness = 17.25 mg/l

Removal of temporary hardness -

① **Boiling** -

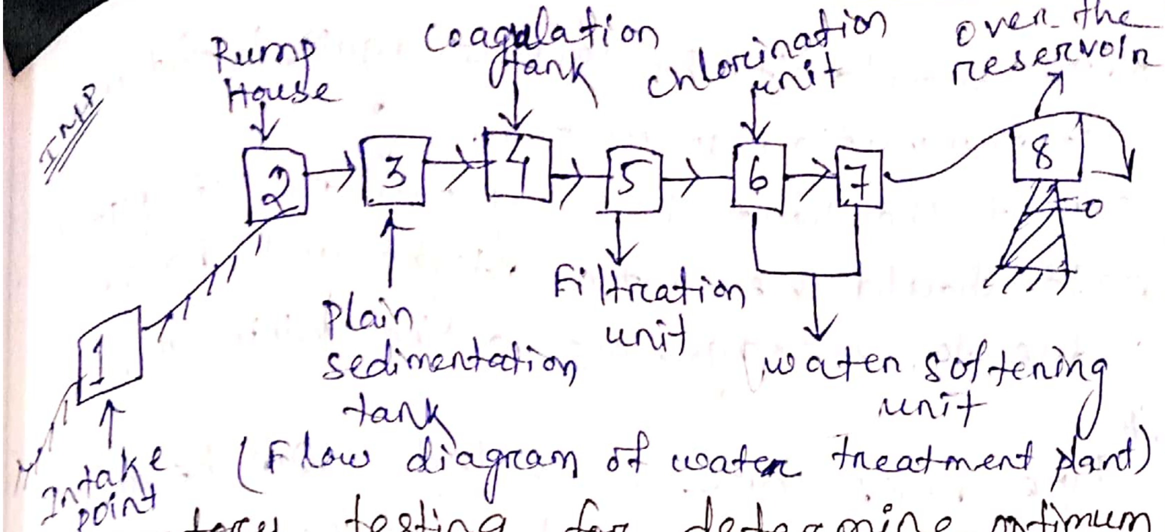
HCO_3 - bicarbonate .

$Ca(HCO_3)_2 + Heat \rightarrow CaCO_3\downarrow + CO_2\uparrow + H_2O$

(insoluble)

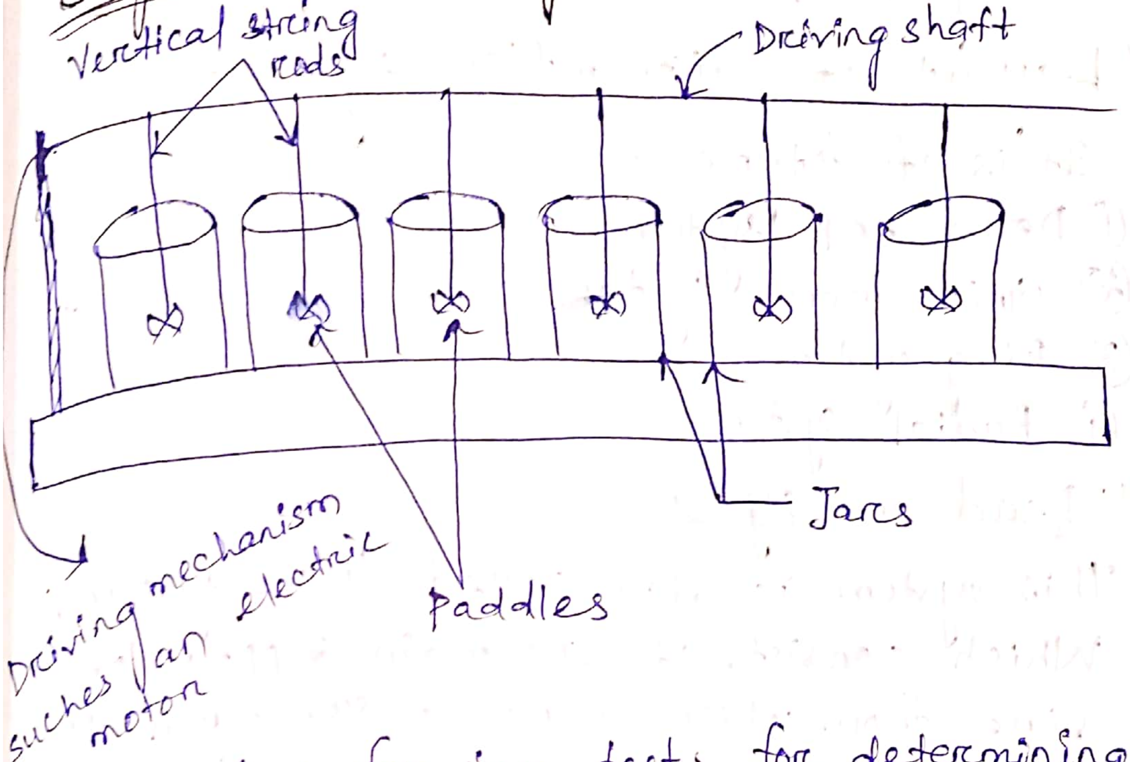
→ It is not use for public water supply.

IMP



(Flow diagram of water treatment plant)

Laboratory testing for determine optimum coagulant quantity – (Jar test) –



Apparatus for jar test. for determining approximate optimum coagulant dosage.

Distribution System –

Requirements of a good distribution system –

① Sufficient pressure head.
② Fire fighting
③ Cheep & economical
④ Easy to operate & repair & RMO cost (Running maintanance & operation) cost should be minimum.

⑤ It shouldn't be safe against future contamination of water.

⑥ That shouldn't be any failure of pipeline.

⑦ It should be water tight and losses due to leakage should be minimum.

* "Pipe lines are provided 2m below of road or foot path surface and 3m away from sewer line."

✓ **Layout of distribution system** –

It is of 4 types –

① Dead end system
② Grid iron system
③ Ring system
④ Radial system

① **Dead end system** –

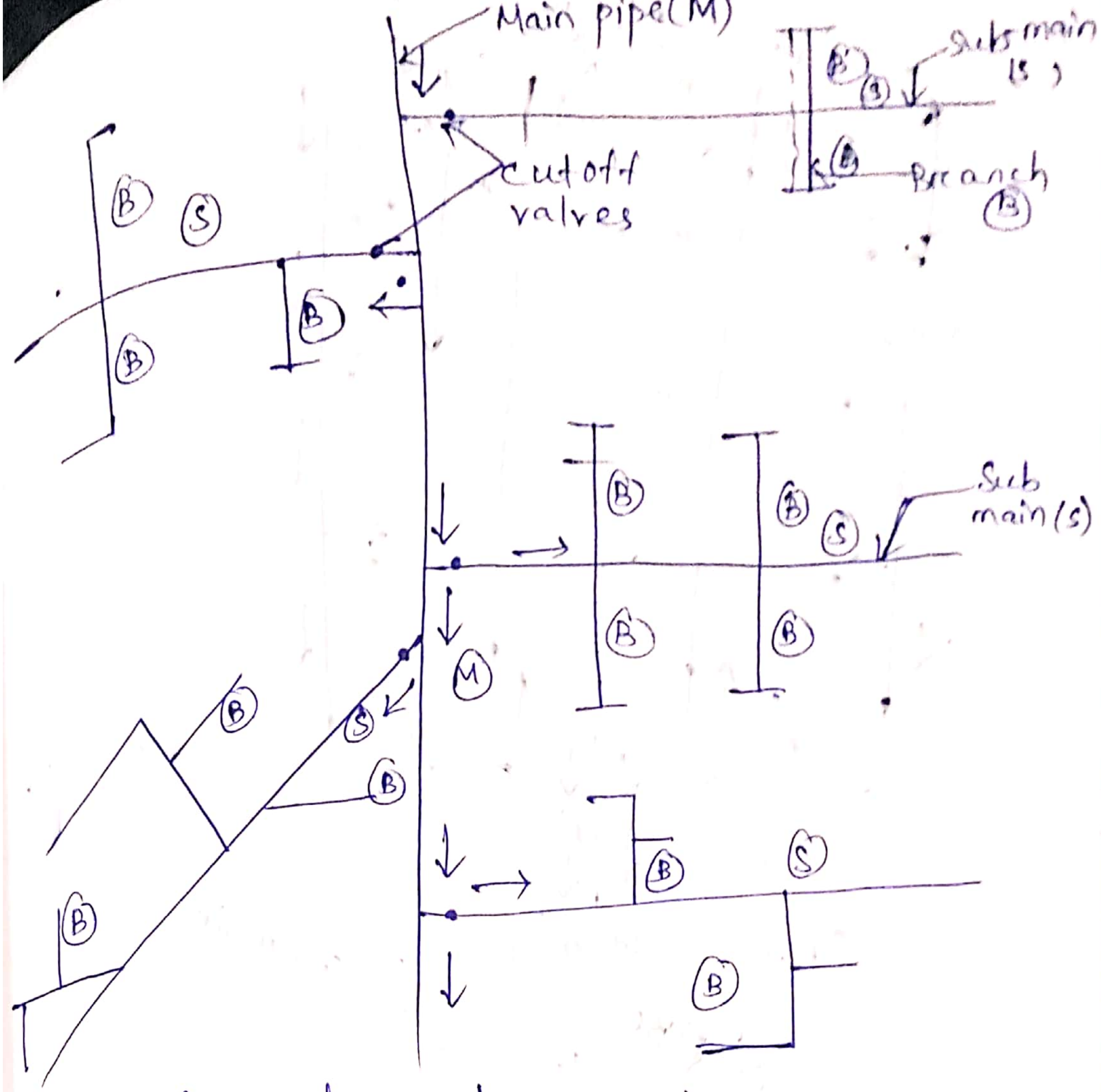
This system is also called tree system. Which consists of one main supply pipe line from which a no. of sub main pipes are originates, which further divides into several branch pipes called laterals.

→ This type of lay out are adopted for older town having development in hapazard manner without proper planning. In this syst a no. of dead ends or termination or end point of pipe line are present.

→ This method is suitable for localities which expands irregularly or randomly

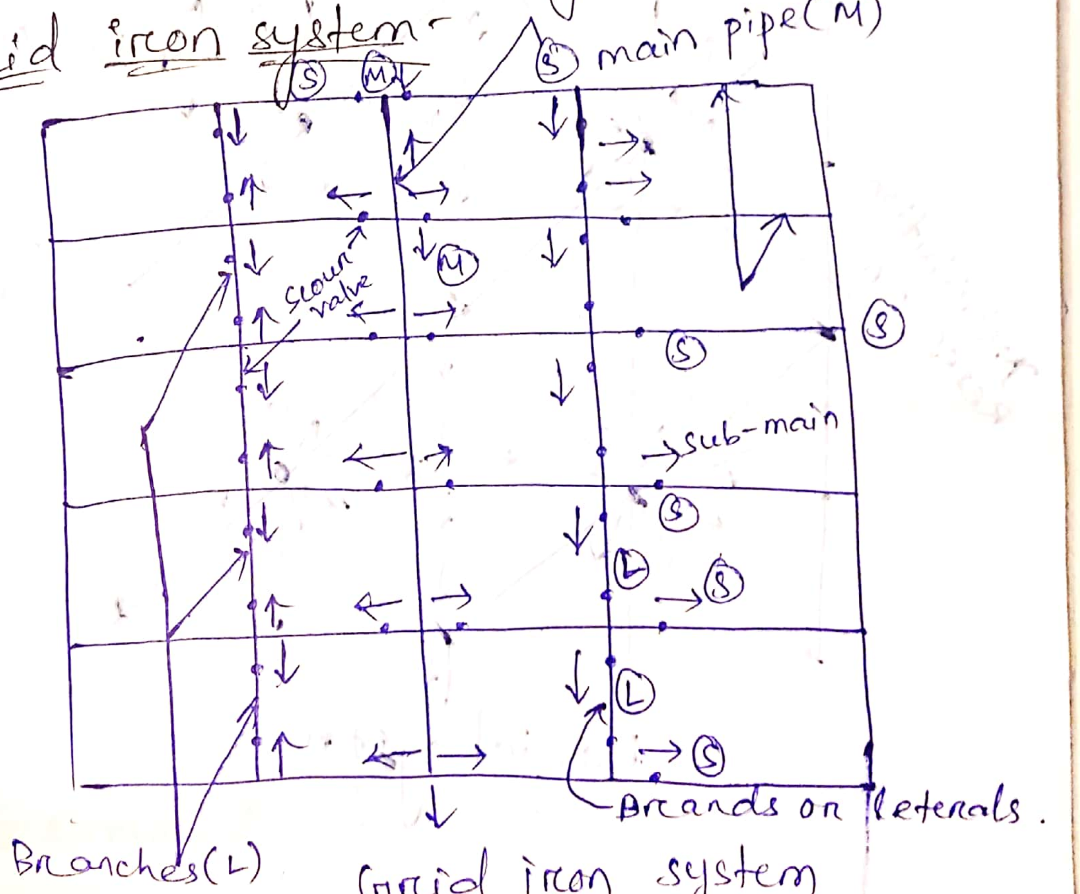
Advantages! –

Disadvantages! –

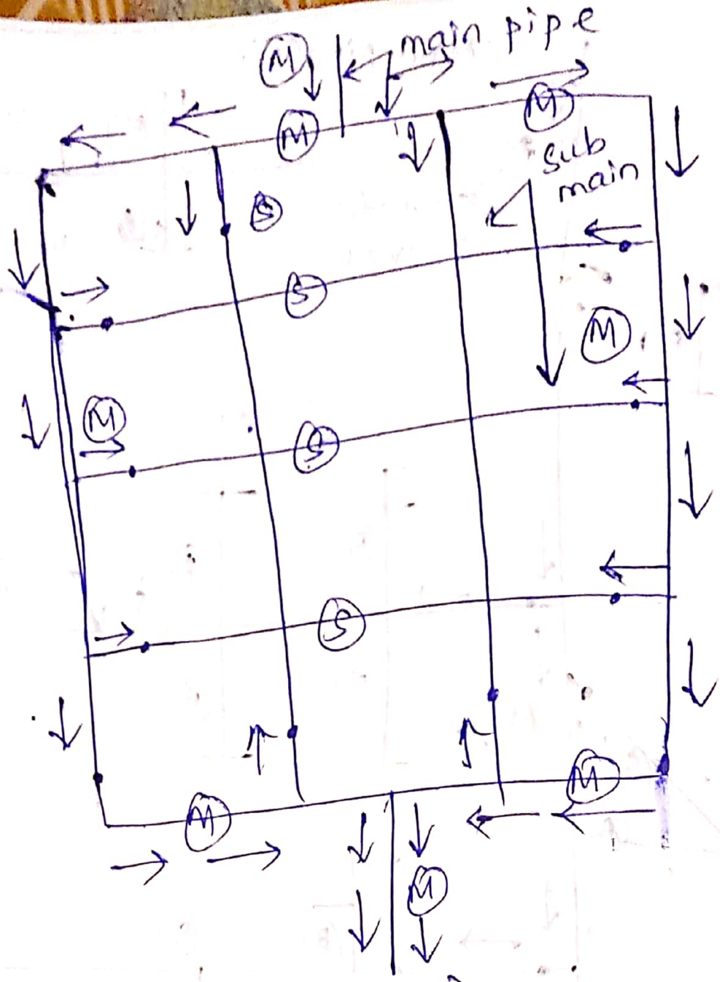


Dead end or tree system.

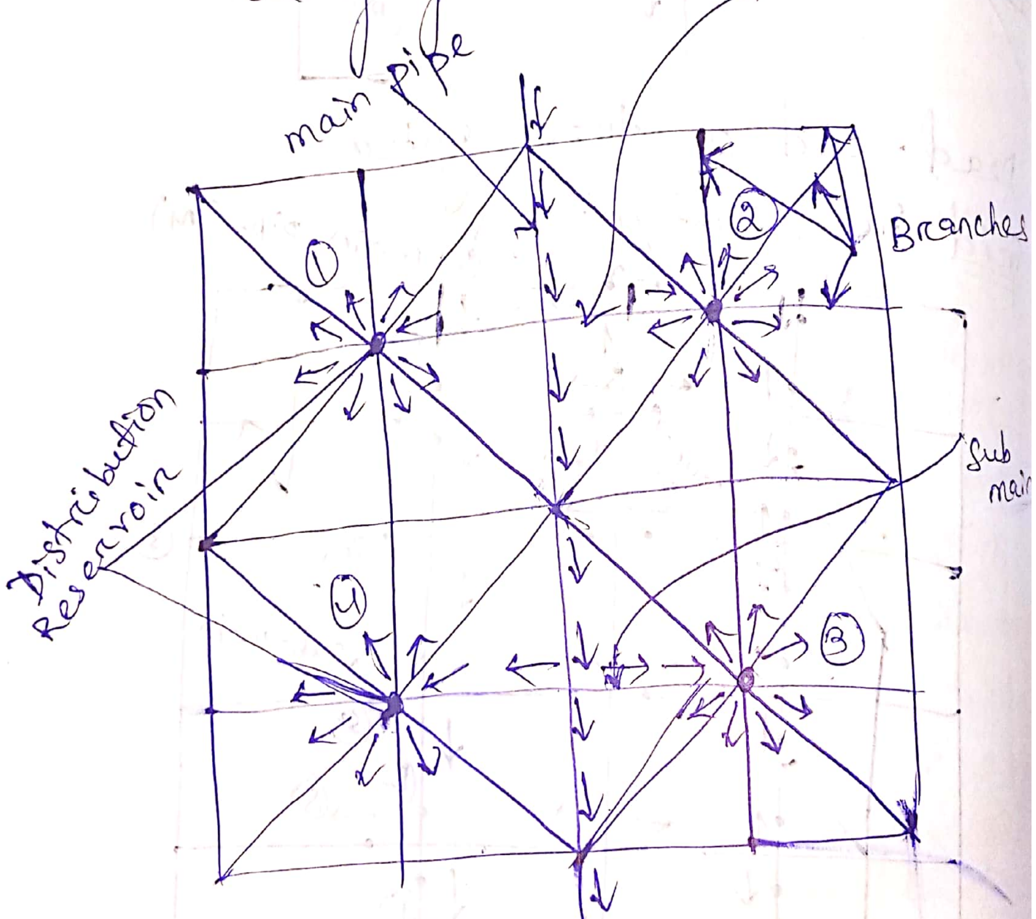
② Grid iron system:



Grid iron system



(Ring system)



Radial system

(ii) Grid iron system-

This is also known as reticulation system or interlaced system.

In this system the main, sub main & Braches are all interconnected to eachother. This method is applied in the cities where the roads are in grid iron ~~sy~~ pattern.

Advantages-

Disadvantages-

(iii) Ring system-

This is also called circular system. This is suitable for towns & cities with very well planned road system having a ring road.

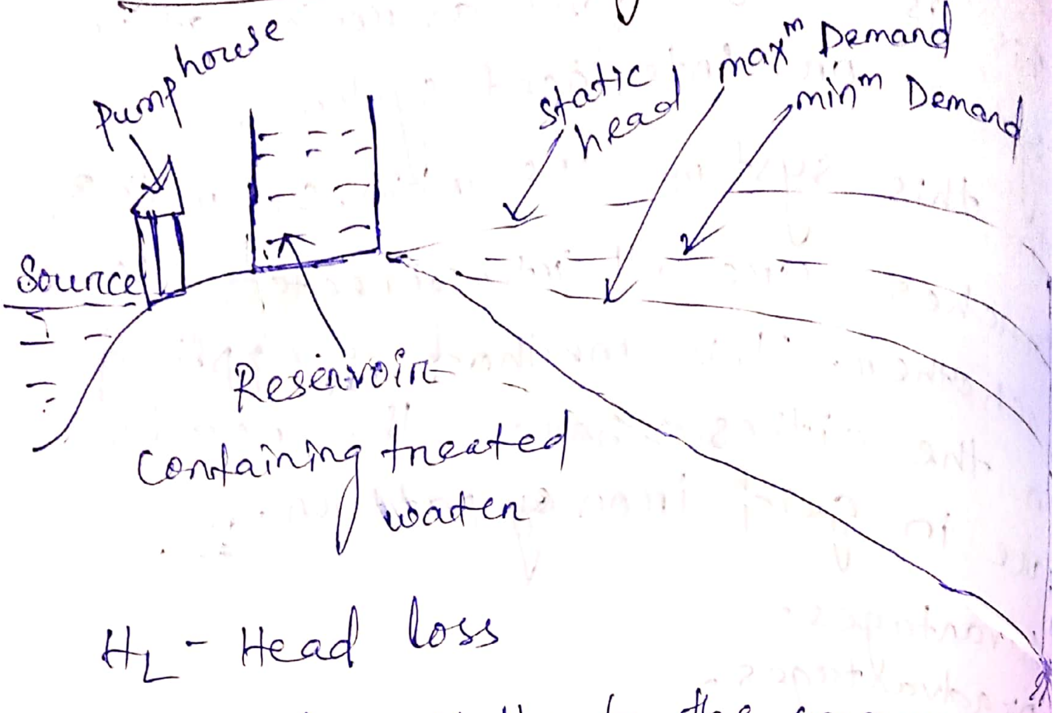
Mojor advantage of this system is at ~~ea~~ every point the pressure of water remains high and the advantage & disadvantage are similar to grid ~~ea~~, iron system.

Method of Distribution-

There are basically 3 systems

① Gravitation system.
② Pumping system
③ combined gravity & pumping system

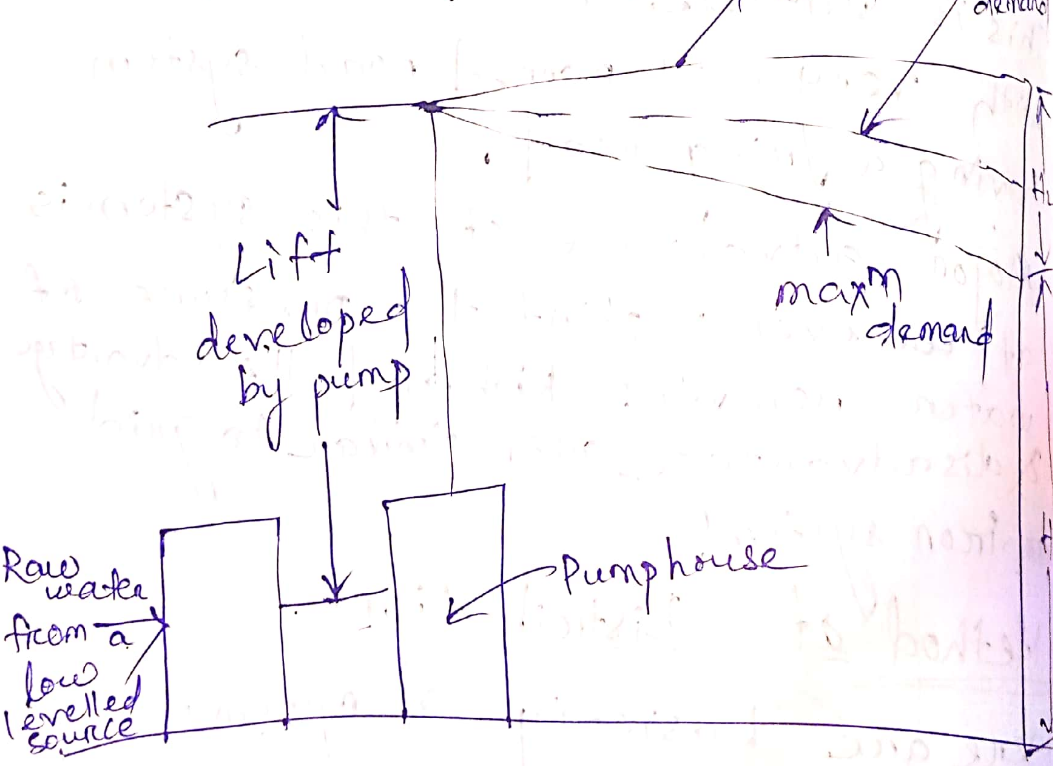
① Gravitational system-



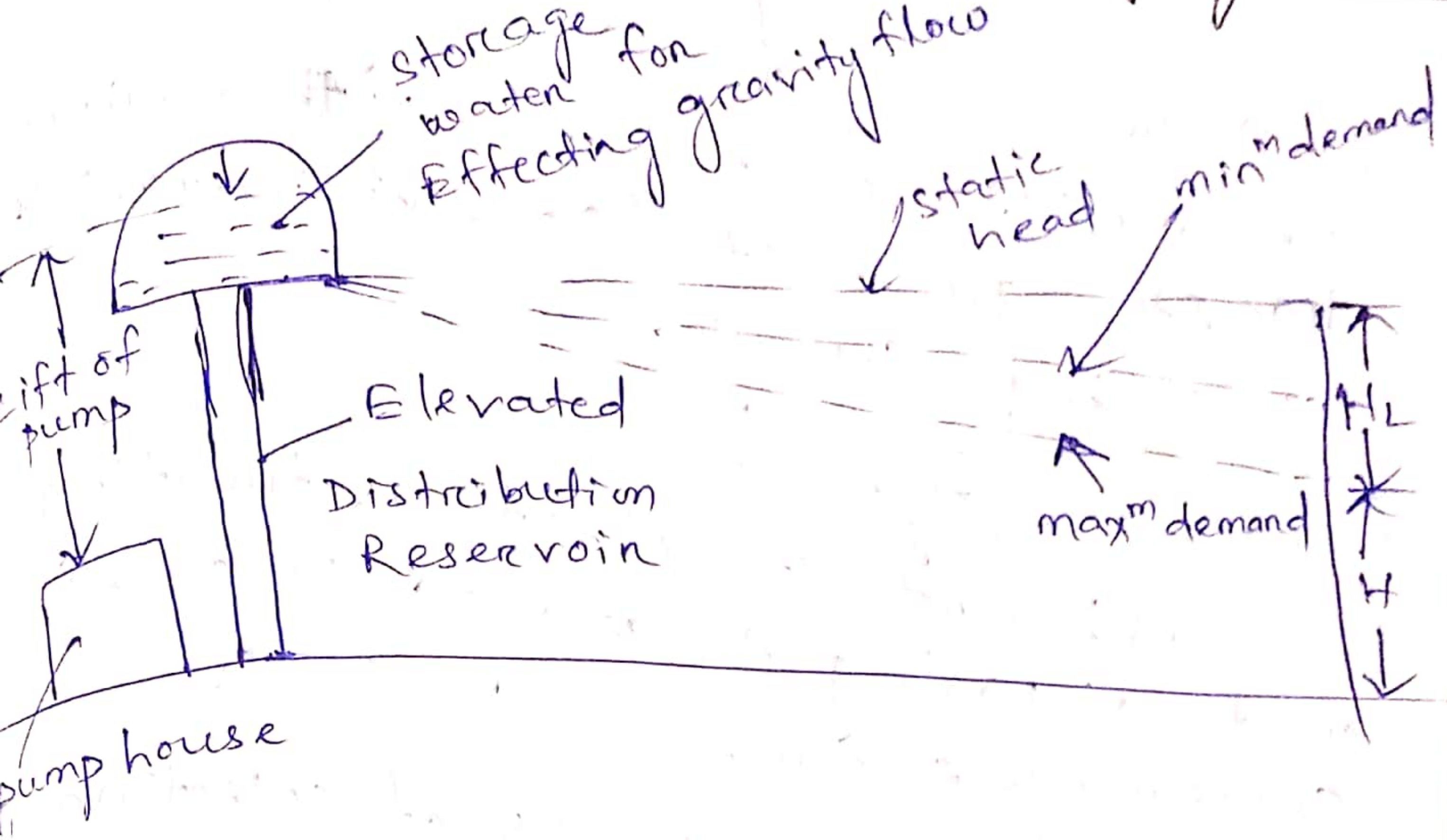
H_L - Head loss

H - head available to the consumer

② Pumping system-



Combined gravity & pumping system



Dt - 19/3/19

Sanitary Engineering

Sewage -

The mixture of water with variou waste products (Domestic, industrial) is called sewage.

Sewerage system -

It is the art of collecting, treating and disposing the sewage is called sewerage system.

→ There are two methods of collecting the sewerage or waste products

① Old conservancy system

② Water carried sewarage system.

Sewer line -

Under ground drainage system is called sewer line.

Types of sewage & types of sewerage system

Sewage → ① Domestic sewage

→ ② Industrial sewage

→ ③ Storm water

Sewerage system –

① Combined system
② Separate system (more preferable)
③ Partially separate system.

Chezy's formula

$V = C\sqrt{rs}$

V- disered velocity
S = slope longitudinal
$r = \frac{A}{P} = \frac{\text{Area}}{\text{wetted perimeter}}$.
c = chezy's constant

Manning's formula

$$V = \frac{1}{n} r^{2/3} s^{1/2}$$

Problem –

Calculate the velocity of flow in a sewer of dia. 1.2 m. The sewer is laid at a gradient of 1 in 400. what will be the discharge through the sewer when running 1½ full. Assume n = 0.012.

$n = 0.012$
$D = 1.2\,m$
$S = \frac{1}{400}$

$$r = \frac{A}{P} = \frac{\frac{\cancel{\pi}}{\cancel{4}_2} D^{\cancel{2}}}{\frac{\cancel{\pi D}}{\cancel{2}}} = \frac{D}{2} = \frac{1.2}{2} = 0.6\,m.$$

$$V = \frac{1}{n} r^{2/3} s^{1/2} = \frac{1}{0.012} \times (0.6)^{2/3} \times \left(\frac{1}{400}\right)^{1/2}$$

$$= 83.33 \times 0.711 \times 0.05$$
$$= 2.96\ m$$

$$Q = A \times V = \frac{\pi}{4} D^2 \times 2.96$$

$$= 1.131 \times 2.96$$

$$= 3.35 \text{ m}^3/\text{s}$$

Q) Calculate the velocity, discharge and chezy's coefficient for a Stone wear sewer running full. Dia. of sewer is 150 mm having gradient of 1 in 60. Assume $n = 0.013$ in manning's formula.

$$D = 150\text{mm} = 0.15 \text{ m}$$

$$S = \frac{1}{60}$$

$$n = 0.013$$

$$r = \frac{A}{P} = \frac{D}{4} = \frac{0.15}{4} = \overset{0.037}{\cancel{0.075}}$$

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

$$= \frac{1}{0.013} \times (\overset{0.037}{\cancel{0.075}})^{2/3} \times \left(\frac{1}{60}\right)^{1/2}$$

$$= 76.92 \times \overset{0.111}{\cancel{0.178}} \times 0.129$$

$$= \cancel{0.766 \text{ m}}\ 1.101 \text{ m}$$

$$Q = A \times V = \frac{\pi}{4} D^2 \times \overset{1.101}{\cancel{1.786}}$$

$$= 0.018 \times \overset{1.100}{\cancel{1.786}}$$

$$= \overset{0.02}{\cancel{0.0321}} \ m^3/s$$

for chezy's formula.

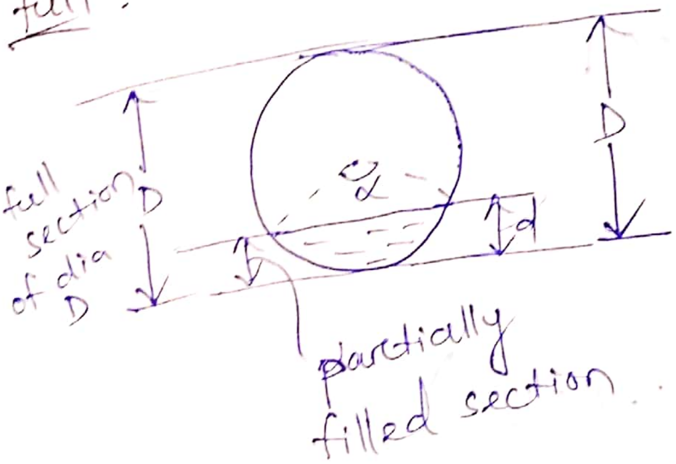
$$V = C\sqrt{rS}$$

$$\overset{1.101}{\cancel{1.786}} = C\sqrt{0.037 \times \frac{1}{60}}$$

$$1.101 = C \times 0.024$$

$$C = \frac{1.104}{0.024} = 45.833$$

Hydraulic characteristics of circular sewer system running full or partially full :-



Depth of partial flow $d = \left[\frac{D}{2} - \frac{D}{2}\cos\frac{\alpha}{2}\right]$

proportionate depth $= \frac{d}{D} = \frac{1}{2}\left(1 - \cos\frac{\alpha}{2}\right)$

Area a, $a = \frac{\pi D^2}{4}\left(\frac{\alpha}{360^\circ} - \frac{\sin\alpha}{2\pi}\right)$

proportionate area $= \frac{a}{A} = \left(\frac{\alpha}{360} - \frac{\sin\alpha}{2\pi}\right)$

wetted perimeter, $P = \frac{\pi D \alpha}{360^\circ}$

Hydraulic mean Depth, $r = \frac{a}{P} = \frac{D}{4}\left(1 - \frac{360^\circ \sin}{2\pi\alpha}\right.$

Q) Determine the size of a circular sewer for a discharge of 600 l/s running half ~~through~~ full. Assume i = 0.0 and n = 0.015.

$Q = 600\ l/s$

$1\ m^3 = 1000\ l/s$

$1\ l/s = \frac{1}{1000}\ m^3 = 0.001\ m^3$

$600\ l/s = 0.001 \times 600 = 0.6\ m^3$

$i = 0.0001$

$n = 0.015$

$\frac{d}{D} = \frac{1}{2}$

$\frac{d}{D} = \frac{1}{2}\left(1 - \cos\frac{\alpha}{2}\right)$

$\cancel{\frac{1}{2}} = \cancel{\frac{1}{2}}\left(1 - \cos\frac{\alpha}{2}\right)$

$\left(1 - \cos\frac{\alpha}{2}\right) = 1$

$\cos\frac{\alpha}{2} = 1 - 1 = 0$

$\Rightarrow \frac{\alpha}{2} = 90°$

$\Rightarrow \alpha = 90° \times 2 = 180°$

Area, $a = \frac{\pi D^2}{4}\left(\frac{\alpha}{360°} - \frac{\sin\alpha}{2\pi}\right)$

$= \frac{\pi}{4} D^2 \left(\frac{180°}{360°} - \frac{\sin 180°}{2\pi}\right)$

$= \frac{\pi}{4} D^2 (0.5 - 0)$

$= 0.39 D^2$ or $\frac{\pi}{8} D^2$

$P = \frac{\pi D \alpha}{360°} = \pi D \frac{\cancel{180°}}{\cancel{360}\,2} = \frac{\pi D}{2}$

$r = \frac{a}{P} = \frac{\frac{\cancel{\pi} D^{\cancel{2}}}{\cancel{8}\,4}}{\frac{\cancel{\pi D}}{\cancel{2}}} = \frac{D}{4}$

$V = \frac{1}{n} r^{2/3} i^{1/2}$

$Q = A \times V$

0.015

$0.6 = \frac{\pi}{8} D^2 \times \frac{1}{n} r^{2/3} i^{1/2}$

$= \frac{\pi}{8} D^2 \times \frac{1}{0.015} \times \left(\frac{D}{4}\right)^{2/3} \times (0.0001)^{1/2}$

$= \frac{\pi}{8} D^2 \times \frac{1}{0.015} \times \frac{D^{2/3}}{2.52} \times 0.01$

$0.6 = 0.104\, D^2 \times D^{2/3} = 0.104 \times D^{2.67}$

$$0.104\, D^{2.67} = 0.6$$

$$D^{2.67} = \frac{0.6}{0.104}$$

$$D^{2.67} = 5.769$$

$$D = 1.93\ m$$

$$= 2\ M$$

Q) Calculate the dia. ~~&~~ & discharg of a circular sewer laid at a slope of 1 in 400 when it is running half full and with a velocity of 1.9 m/s. (n = 0.012)

$S = \frac{1}{400}$ $\qquad A = \frac{\pi D^2}{8}$

$V = 1.9\ m/s$

$n = 0.012$

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

$$1.9 = \frac{1}{0.012} \times R^{2/3} \left(\frac{1}{400}\right)^{1/2}$$

$$1.9 = 83.33 \times R^{2/3} \times 0.05$$

$$R^{2/3} = \frac{1.9}{83.33 \times 0.05} = 0.46\ m.$$

$R = 0.312$ m.

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

$\frac{D}{4} = 0.312$

$D = 0.312 \times 4 = 1.248$

$Q = A \times V$

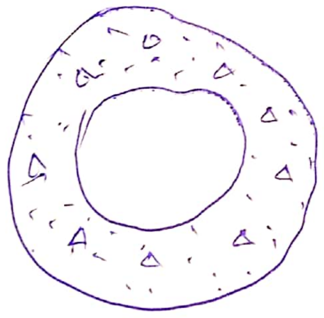
$= \frac{\pi D^2}{8} \times V$

$= \frac{\pi (1.248)^2}{8} \times 1.9$

$= \frac{2.324}{2}$ m³/s

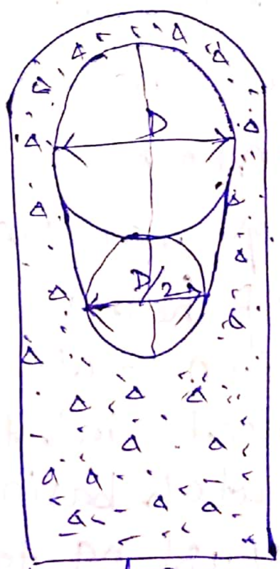
$= 1.162$ m³/s

Different types of sewers-

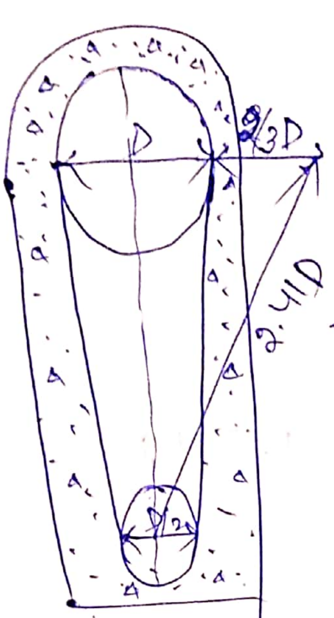


(Circular shaped sewer (most widely used for all types of sewers)

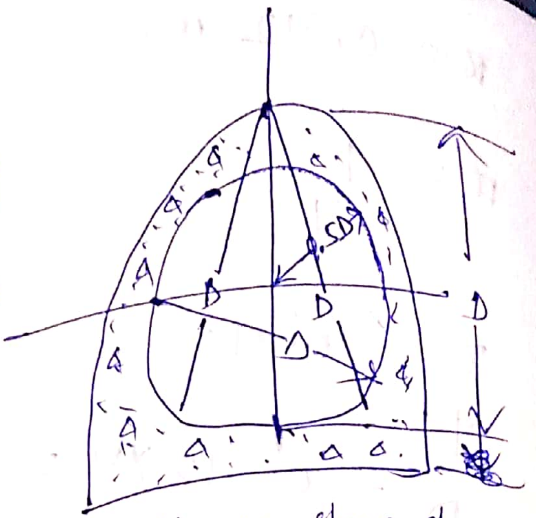
&



Standard Egg-shaped sewer (may be perferred for combined sewers)



New egg shaped sewer (may be preferred combined Sewers)



Horse shoe shaped sewer (may be used for large sewer with heavy discharge such as for trunk and out fall sewers)

Sewer appurtenances :-

The structure which are constructed at suitable interval along the sewerage system to help its efficient operation & maintainance are called sewer appurtenances.

These includes -

(i) Manholes
(ii) Drop manholes
(iii) Lamp holes
(iv) clean outs
(v) street inlets called gullies
(vi) Catch basin
(vii) flushing tanks
(viii) greasel & oil traps

(i) Inverted siphons
(j) strom regulator.

i) **Manholes** -
Manhole is made of mosonry or RCC chamber constructed at suitable interval along the sewer line for providing access into them. these helps in inspection, cleaning and maintenance of sewer.

These are provided at every bend, & junction; change of gradient or change of dia. of the sewer.

→ It is of 3 type.

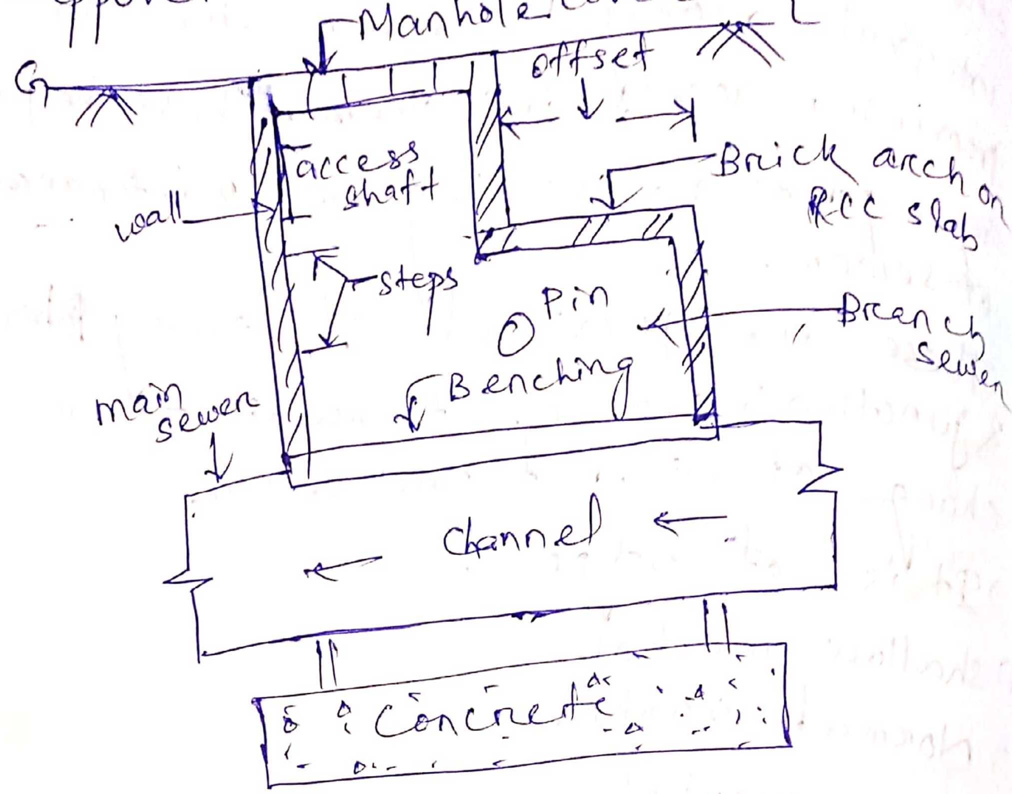
① shallow manhole
② Normal manhole
③ Deep manhole.

Shallow manhole -
shallow manhole is of 0.7 to 0.9m depth constructed of the start of branch sewer or at places not subjected to heavy traffic.

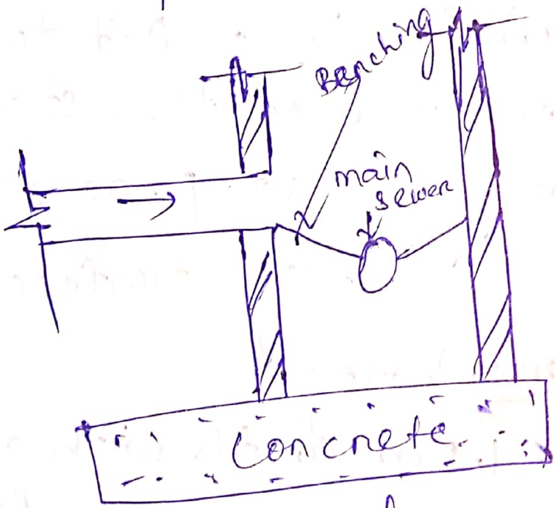
Normal manhole -
These are 1.5m depth with dimensions 1m×1m (square) or 1.2×0.9m (~~regul~~ rectangular)

Deep manhole -
The depth of these manhole is more than 1.5m. The size in upper portion

is reduced by providing an offset
Steps are provided for descendin
into manhole. These are provided
with every cover at its stop to
support traffic load.



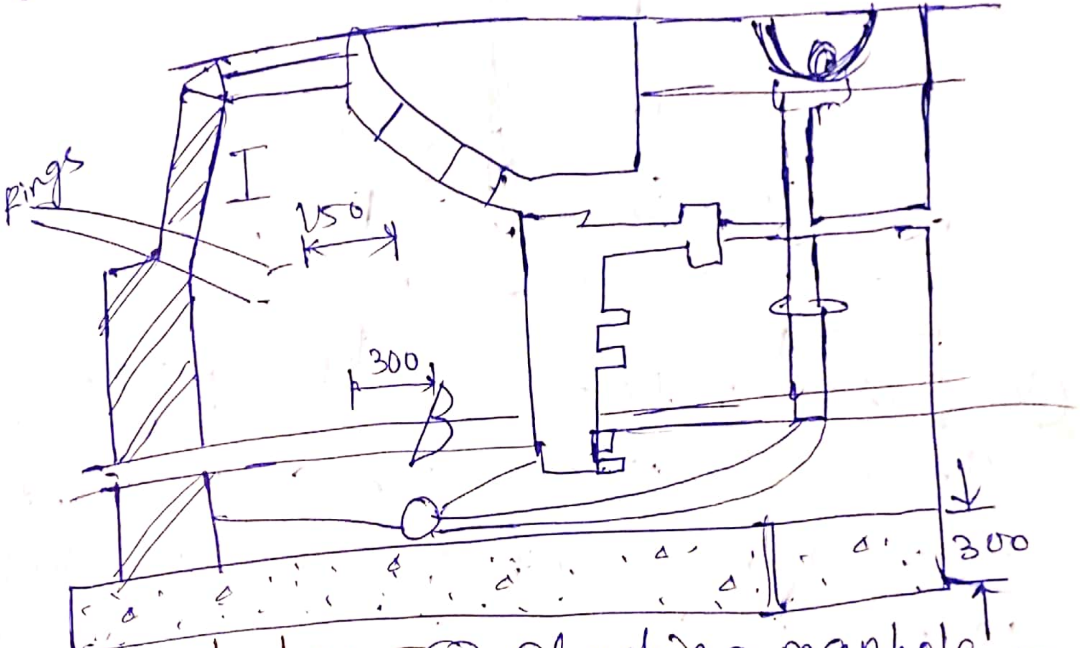
(Deep man hole)



channel
section AB
(Bottom of manhole)

(ii) DROP manhole:-

When a sewer connects with another sewer and the difference of level & branch sewer and main sewer is greater than 0.6 m then a manhole may be filled either with vertical or slope droped pipe from higher sewer to the lower one. This is called drop manhole.

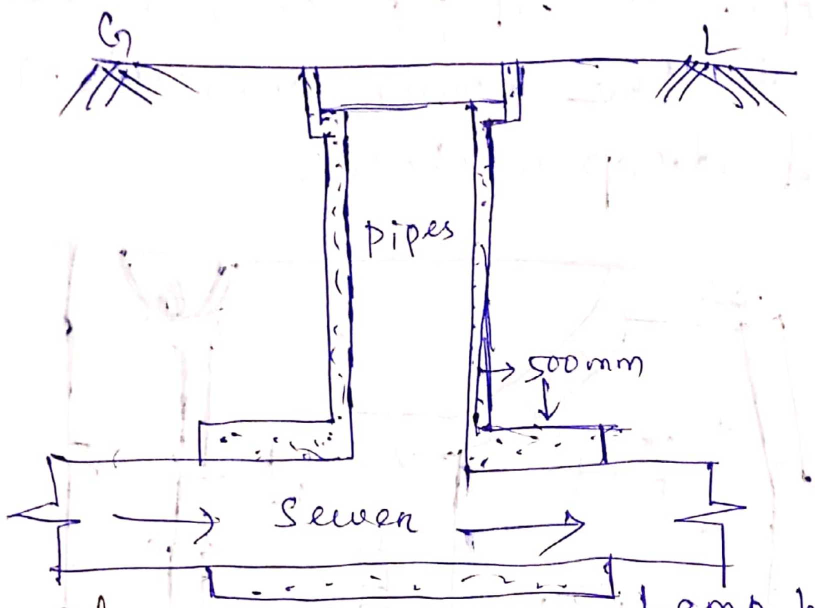


~~(iii) Lamp holes~~ (iii) Flushing manhole:-

In a flat ground for branch sewer when it is not possible to obtain self cleaning velocity, it is necessary to install a flushing device at a distance of 45 to 50 m in the sewer line & water flushed to the sewer and washed the deposited weast solid inside the sewer.

(IV) Lamphole –

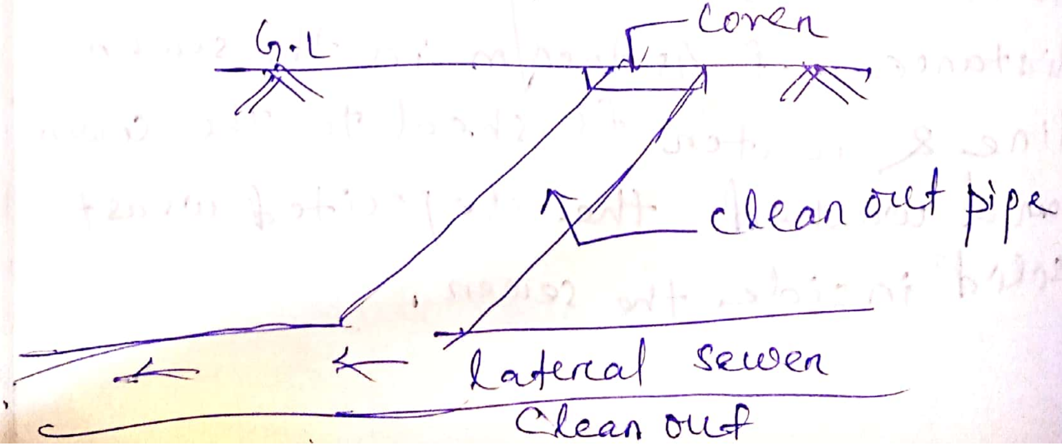
It is an opening or hole constructi in a sewer for the purpose of lowering a lamp inside it. These are used for inspection, flushin & ventilation.



Lamp hole

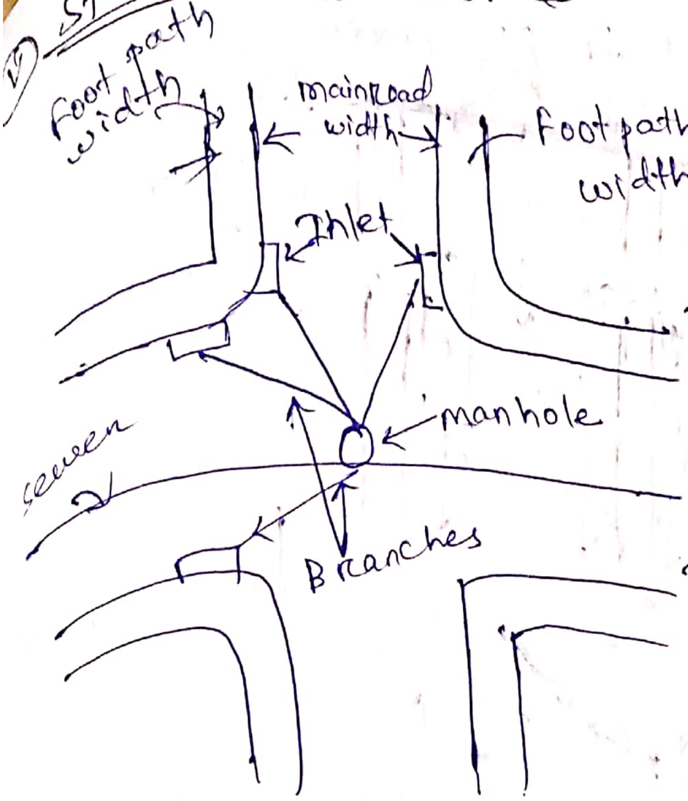
(IV) Clean outs –

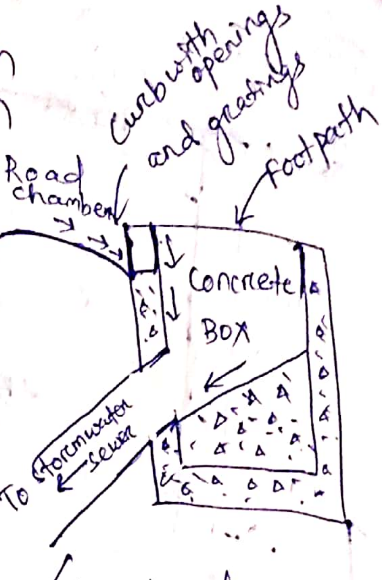
It is a pipe which connected to the underground sewer through whic water is forced through lateral sewer to remove obstacle in the sewer line. For large obstacle flexibl rods may be used through the clean out pipe.



Clean out

V) Street inlets :-



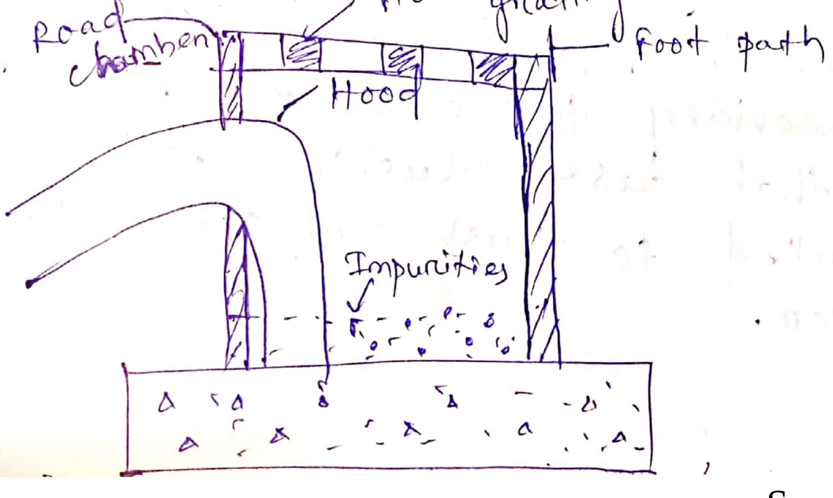


(vertical Inlet or curb inlet)

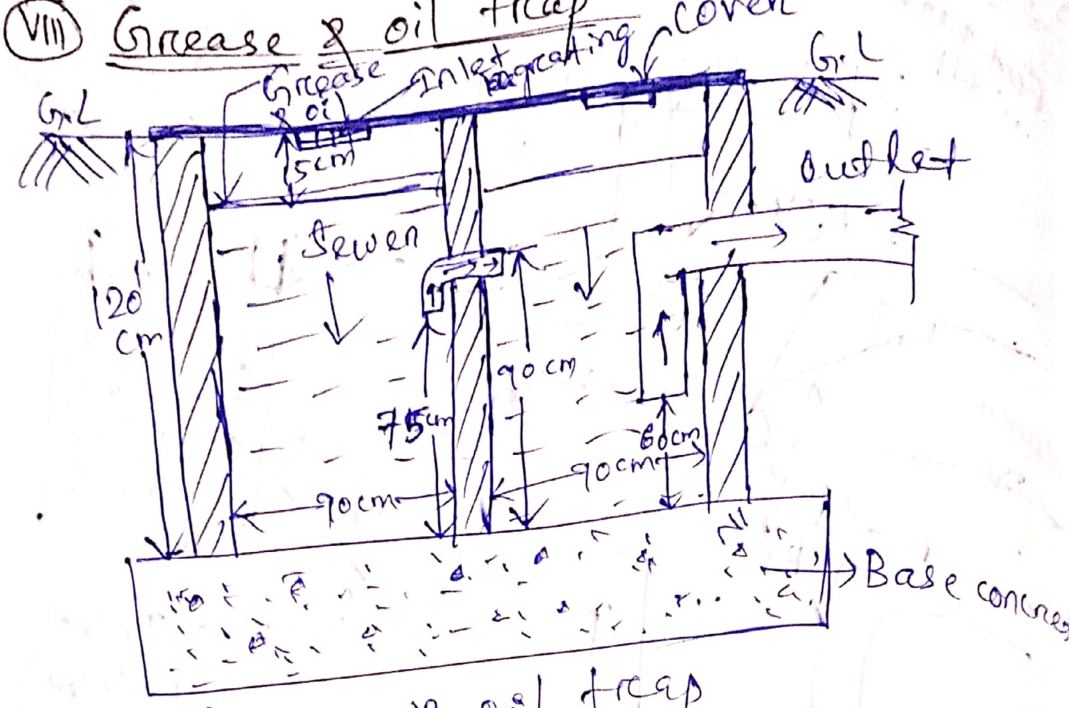
Showing the location of storm sewer Inlets at streets intersection.

VI) Catch basin or Catch pits -

These are the Street inlets provided with additional small sattling machine. Grid, sand, debris etc sattled in this machine and are prevented to flow into the sewer. A hood is also provided to prevent the escape of whole case.



(VIII) Grease & oil trap-



Grease & oil trap

These are the chambers which are constructed in a sewerage system to remove oil & grease from the sewage before it enters to the sewer line.

→ These are constructed near workshop, garrages, kitchens of hotels, industries etc.

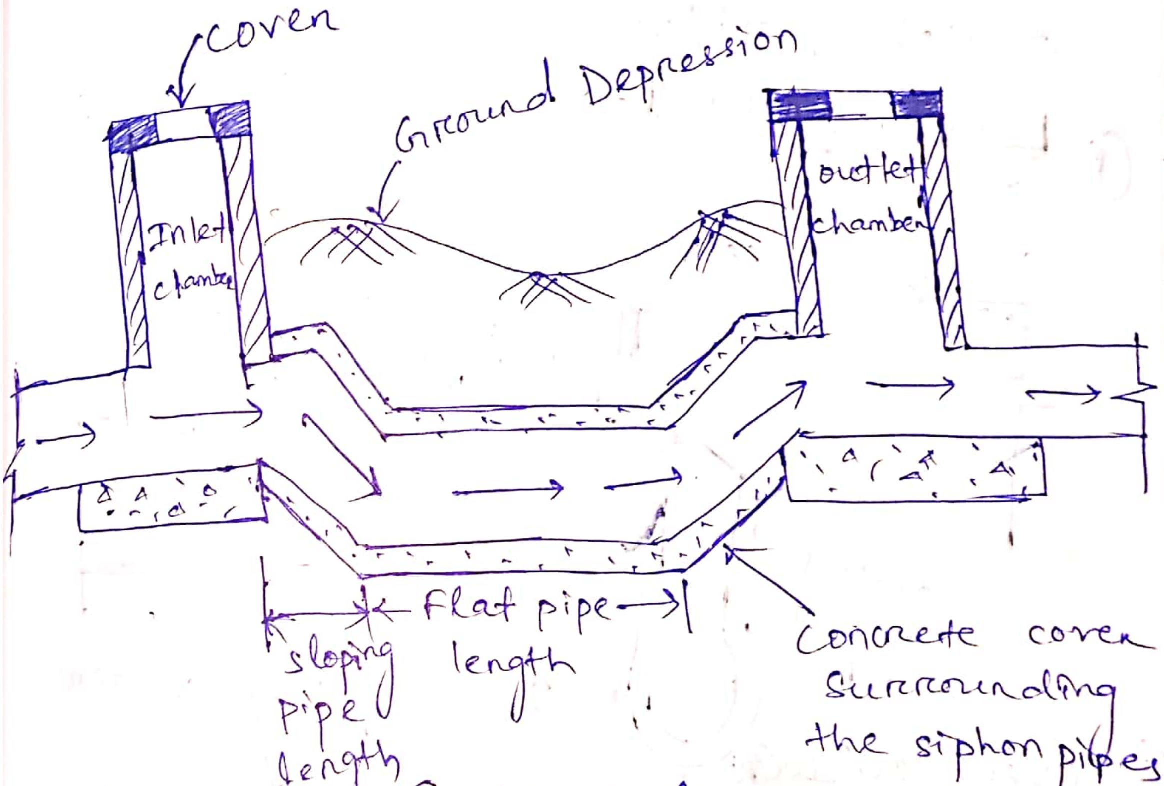
(VII) Flushing tank-

In flat gradient of sewer line it where the self cleaning velocity can't be provided to the ~~sewer~~ sewage in that case flushing devices are installed to flush and clean the sewer.

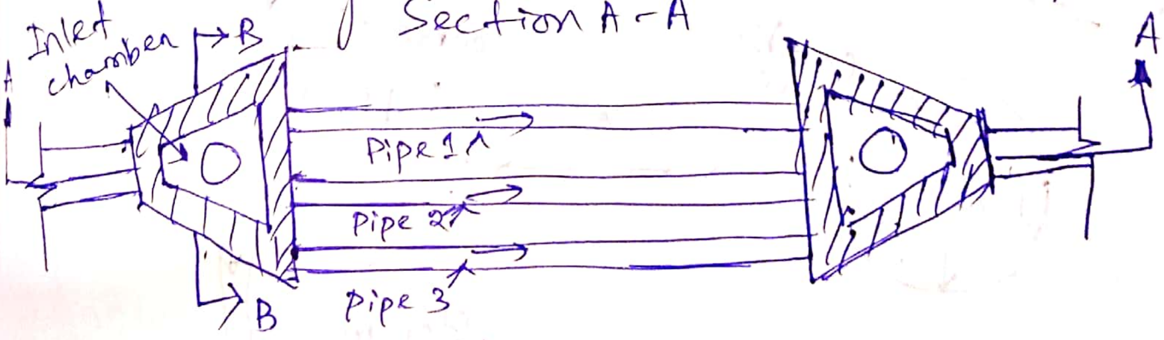
Q) Inverted siphon -

Whenever a sewer pipe has to be droped below the hydraulic gradient line for passing it below a valley, road, railway or a stream or ~~alred~~ any other depression then it is known as inverted siphon.

The sewage incase of inverted siphon will flow with siphonic pressure.



Section A - A



PLAN

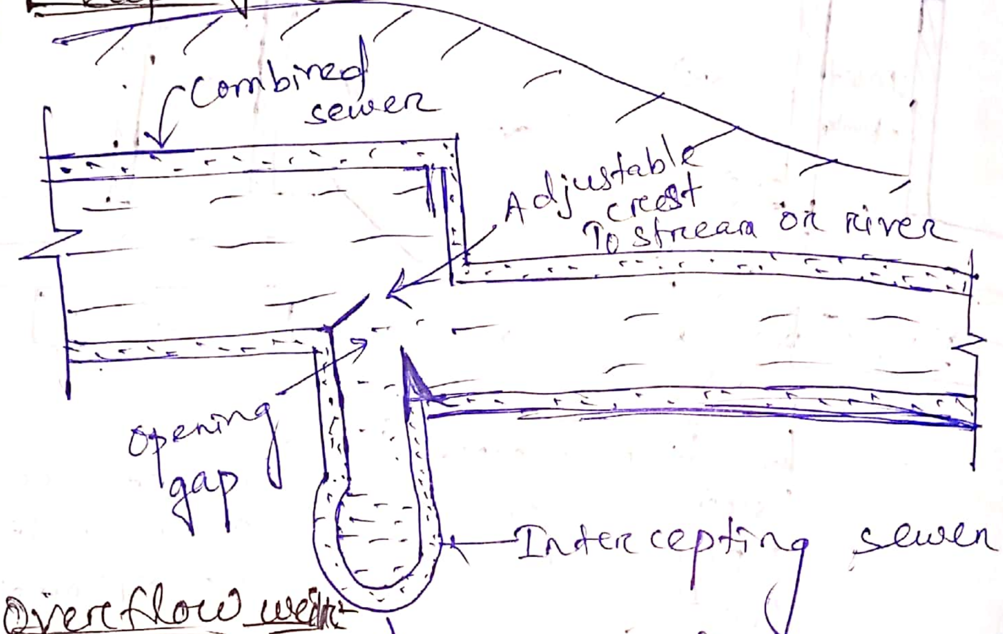
⑧ Storm water regulator :- or storm relief wall

These are constructed in combined sewerage system and permit the diversion of excess storm water into a near by stream.

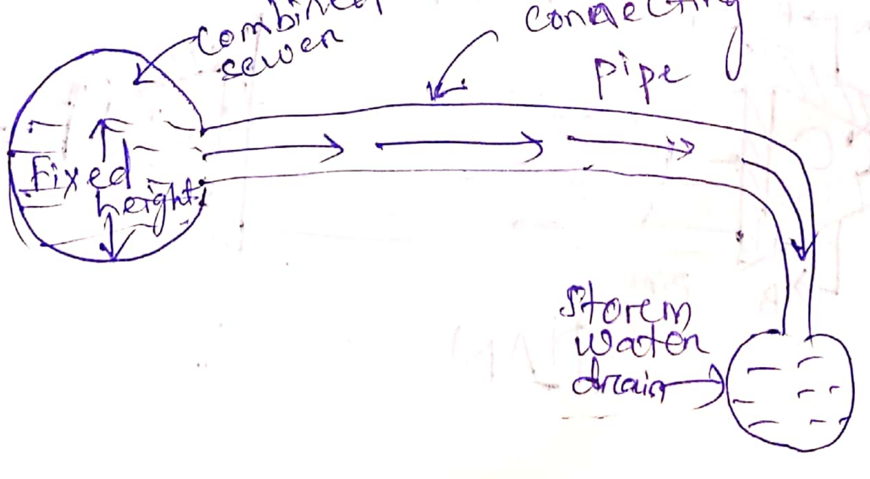
It is of 3 types -

① Leaping weir
② Overflow weir
③ Siphon spillway

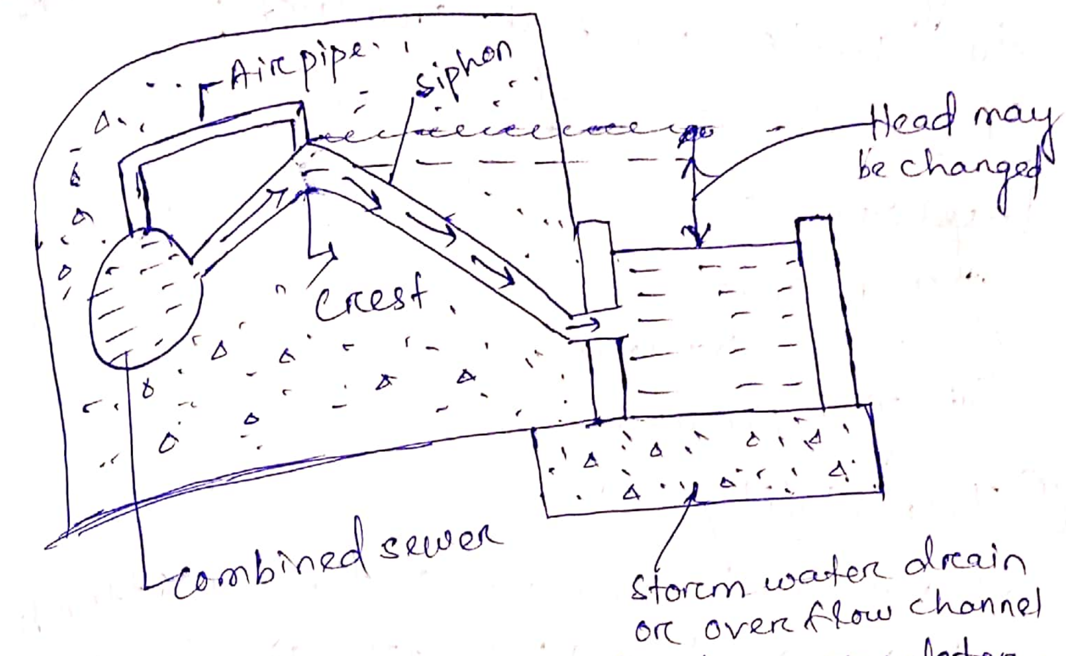
① Leaping weir -



(II) Overflow weir



③ Siphon spillway -



Siphon spillway type of storm regulator -

Ch- Quality & Characteristics of sewage :-

There are two types of biological decomposition of organic matter -

① Aerobic decomposition
or aerobic oxidation

② Anaerobic decomposition
or putrefaction.

① Aerobic decomposition -

If oxygen is available freely to the waste water in dissolved form then the biodegradable organic matter under go aerobic decomposition by aerobic bacteria, ~~and~~ and facultative bacteria.

② Anaerobic decomposition -

If free oxygen is not available then anaerobic decomposition will occur.

then anaerobic bacteria & facultative bacte will consume the molecular bonded oxygen and oxidised the organic matter to stable and end product.

Characteristics of sewage -

Physical characteristics -

(i) Turbidity
(ii) Colour & odour
(iii) Temperature.

(1) Turbidity -

Sewage is having floating matter lik animal or human waste products, paper pieces, cigaratte & machstick, vegetable & food debris, soap, grease & oil. These matters will increase the turbidity of waste water. As the turbidity increases the sewage becomes more stronger.

→ Turbidity can be measured by turbidity rod or turbidymeter.

(2) Colour -

→ fresh sewage is yellowish, grey or light brown in colour.

→ Septic sewage is black or dark brown in colour.

(3) Odour -

→ fresh sewage is odourless.

→ Septic or steal sewage omit offency odour due to decomposition of organic odour.

mainly due to Hydrogen sulphite case.
it is measured by threshold odour no.

$$TON = \frac{V_s + V_p}{V_s}$$ where, V_s - volume of sewage.
V_p . volume of distilled & odourless water

1) temperature -

Avg. temp. of sewage in India is 20°C.
which is ideal for biological activity.
when temp. increases amount of Dissolved oxygen decreases.

chemical characteristics -

1) Total suspended & settleable solids -

Suspended solids are floating in the sewage. Dissolved solids and remained dissolved in water as colloidal solids are finely divided solid either in solution or suspension.
Settleable solids are the solids which settles out of sewage is allow to remain undisturbed for a period of 2hrs. ~~Also~~

- → Total solid S_1 determined by evaporation of a known volume of sewage sample.
- → Suspended solid S_2 are found out by filtering the sewage sample.
- → Dissolved solid $S_3 = S_1 - S_2$.
- → The total suspended solids are either volatile or fixed.

If aften filtration the dried resid is ~~ig~~ ingnited at 550°C for 15to20min then the loss of weight will give vola solid (S_4). Fixed solid (S_5) = $S_2 - S_4$. Settleable solid (S_6) determined by imhoff form.

② PH value :-

$$PH = -\log_{10}[H^+]$$

$$H^+ = (10)^{-PH}$$

It is measured by potentiometer.

Fresh sewage is generally alkaline in nature, but aften ~~some~~ time due to decomposition the sewage becomes acidic.

③ Chloride contain :-

It is due to kitchen waste, animal and human waste product, urine, ice-cream ~~tea~~ pan etc.

For domestic sewage chlorid contained is 120mg/l.

It is measured by titrating the waste water with standard AgN soln., using ~~$KMnO_4$ as~~ pottasium chromate as indicator.

① Nitrogen contain -

There are 4 types of nitrogeneous compound.

① ~~pre~~ free Amonia NH_3 called Amonia nitrogen.

② Albuminoid nitrogen or organic nitrogen.

③ Nitrate

④ Nitrite.

→ free amonia indicates 1st stage of decomposition.

→ Albuminoid nitrogen indicates quantity of nitrogen before decomposition of organ matter.

→ Nitrite indicates partly decomposed organic matter.

→ Nitrate indicates fully oxidised organic matter.

→ Nitrate is fin~~al~~ stable, end product which is not harmful but if its concentration in water supply is ~~or~~ > 45 ppm then it will cause nitrite poisoning in infant. (blue baby ~~sign~~ deasease)

→ Free amonia is measured by boiling the sewage and measuring Amonia gas, Alubiminoid nitrogen measured by adding $KMnO_4$ to a boiled sewage sample and again boiling the same and liberated amonia is measured. If in a unboiled sample is used to add $KMnO_4$ before boiling the prefered amonia gas will measure total amonia nitrogen & organic nitrogen, which is known as kjedahl nitrogen.

- Amount of nitrite and nitrate are measured by colour matching technique.

- ~~Presence of oil, grease~~

⑤ Presence of oil, grease -

A sample of sewage is evaporated then the residual solid are mixed with ether and the solⁿ is evaporated leaving behind fats & greases as residue which can be measured by ~~waiting~~ weighting.

⑥ Dissolved oxygen -

Dissolved oxygen contained measured by winkler's method. which is oxidation reduction process to liberate Iodine and the quantity of Iodine will be give as to quantity of dissolved oxygen.

Chemical oxygen demand — (COD)

It is determined by adding standard soln of $K_2Cr_2O_7$ and heating the sample so that the organic matter is oxidised then the resulting soln is titrated and oxygen used in oxidising the waste water is determined, which gives total organic matter (biodegradable, Non-biodegradable organic matter)

Total organic carbon — (TOC)

carbon is primary ~~component~~ constituent of every organic matter. If we calculate the concentration of carbon in the chemical formula of organic compound then we ~~too~~ find out total organic carbon.

Biochemical oxygen demand (BOD)

The amount of oxygen required for decomposition of sewage by biologically active organic matter.

Standard BOD: 20°C

BOD_5 BOD in 5 days at 20° C (oxygen consumed)

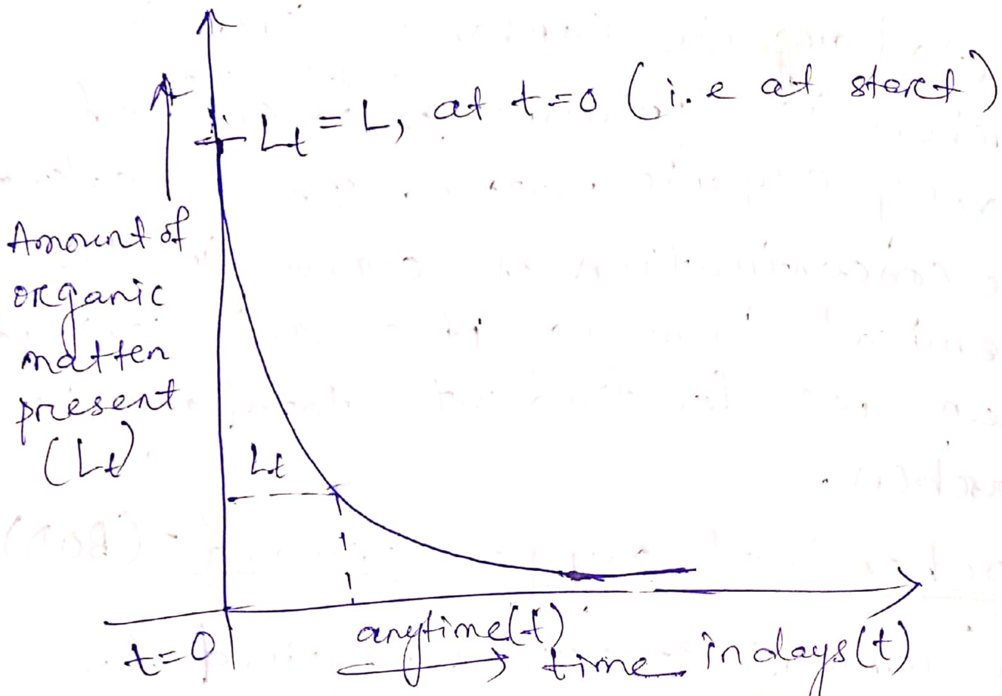
$DO_i > DO_f$

OD or BOD_5 = $[DO_i - DO_f]$ DO consumed in test by diluted sample

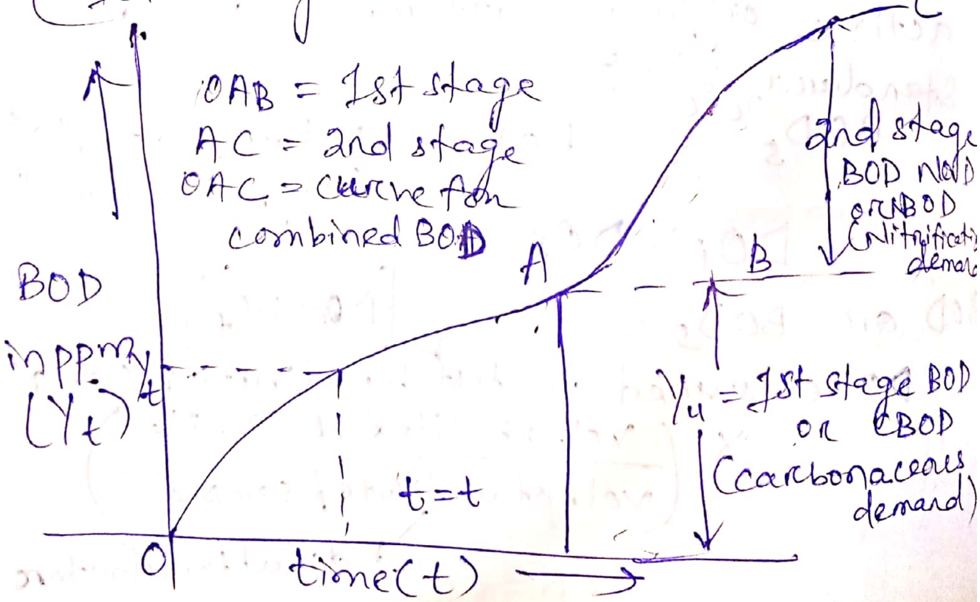
$$\times \left(\frac{\text{vol. of diluted sample}}{\text{vol. of undiluted sample}}\right)$$

→ dilution factor

→ 1st oxygen demand during 1st 20 days is due to oxidation of organic matter is called carbonaceous demand on 1st stage demand on initial demand and at later stage after 20 days the oxygen demand is due to oxidation of amonia which is known nitrogeneous demand on 2nd stage demand.



(1st stage BOD curve)



Population equivalent -

Industrial waste water are generally compared with per capital normal nomestic waste water to charge the industries for the pollution caused by them.

standard BOD for 5 days of industrial sewage = (standard BOD_5 of domestic sewage per person per day) × pop^n equivalent.

Relative stability -

It is defined as the reatio of oxygen available in the effluent to the total ~~sta~~ oxygen required to satisfy its 1st stage BOD.

It is given by $S = 100\left[1-(0.630)^{t_{37}}\right]$

where S = Relative stability

t_{37} = time in days for sewage sample for decolorised a standard volume of methylene blue sol^n when incuvated at 37°C.

For temp 20°C

$$S = 100\left[1-(0.794)^{t_{20}}\right]$$

Dt - 2/4/19

Ch -

Sewage Disposal

Introduction

The study of sources of disposal is important because amount of treatment required to give sewage depends upon quality, capacity to tolerate the impurities present in sewage effluent without getting pollutant.

There are generally two types of Disposal metho

① Dilution - Disposal in water.

② Effluent irrigation or sewage forming - Disposal on land.

Disposal by Dilution -

→ It is the process where the treated sewage or effluent of sewage treatment plant is discharged into river, stream or large body of water like sea. which is purified by self purification process of natural water.

→ The degree & amount of treatment to be given depends on quality of cross sewage, self purification capacity & intendent use of its water.

Conditions favouring disposal by dilution -

① When some natural rivers or water courses are not located in the vicinity, the land treatment is the only alternative left and has to be adopted.

② When irrigation water is scarcely available, the use of sewage for irrigation crops is a good alternative.

③ When large areas of open land are availa broad irrigation may be practised over it with the help of sewage effluents, and good returns can be earned by raising cash crops, Crops like wheat, cotton, sugarcane, plantain, grasses, fodder, coconut, orange trees, etc. have been successfully grown with advantage on sewage farms.

i) The method of effluent irrigation will prove useful in areas of low rainfall, as this will help in maintaining good absorption capacity of the soil.

ii) The area for land treatment or sewage farming should preferably be porous, such as sandy, loamy, or alluvial soils, or soft moorum. It should not be made of heavy retentive soils like clay, etc. which prevent easy aeration of the soil voids, and thus creating anaerobic conditions.

iii) This method of disposal of sewage, poses problems during the periods when no irrigation water is required for the crops especially during rains. This method is, therefore preferred when sewage can be diverted to some river streams.

iv) This method is preferred in areas of low water-table, where rate of percolation may be quite high.

Dilution in river & self purification of Natural stream—

Various natural process which help in self purification are-

① Physical process—

(a) Dilution & Dispersion

(b) Sedimentation

(c) Sunlight

② Chemical process-

(a) Oxidation

(b) Reduction

(234)

Zone of degradation or zone of pollution:

This zone is found below the point of disposal near water becomes dark & turbit with the formataion of slag deposit at the botto. DO is reduced to 40% of saturation value. Here reoxygenation is slower than deoxygenation. These zone is unfavourable for aquatic life.

Zone of active decomposition —

There is heavy pollution in this zone water becomes grey and darker than previous zone. DO$_2$ conc. becomes zero and Anaerobic condition starts with revolution of foul gases, : CH_4, CO_2, H_2S with scum layer formation at the surface. In this zone aquatic life are absent.

Zone of recovery -

In this zone the river water recovers from its dignated conditions, water becomes clearer and BOD falls down and DO rises above 40% of the saturation value.

Zone of cleaner water -

The river attains original conditions with DO rising upto saturation value and usual aquatic life survives. but pathogenic bakteria may also present so if the water is used for drinking water supply then it should be treated properly.

Dilution

The sewage of conc. C_S flows at a rate of Q_S into a river stream with conc. C_R flowing at a rate Q_R than the conc. of the resulting mixture is

$$C = \frac{C_S Q_S + C_R Q_R}{Q_S + Q_R}$$

This formula is applicable separately for the conc. of different impurities, DO, BOD and suspended sediments of sewage.

Formula for BOD—

At a certain temp. the rate of deoxygenation is directly proportional to amount of organic matter present at the sewage at that time.

So, we have $$\frac{dL_t}{dt} = -KL_t$$

where L_t = organic ~~factor~~ matter present in sewage after t days in mg/l.

K = A constant which indicate rate of oxidation.

After simplifying this eqn we get

$$\log_{10}\frac{L_t}{L} = -0.434Kt \quad ①$$

Here $0.434K = K_D$

putting this in eq^n ①

$$\boxed{\log_{10}\frac{L_t}{L} = -K_D t}$$

K_D = BOD rate constant

Deoxygenation constant

$$\log_{10}\frac{L_t}{L} = -K_D t$$

$$\text{or } \frac{L_t}{L} = (10)^{-K_D \cdot t}$$

Here L = organic matter present at starting condition.

If Y_t represents total amount of organic matter oxidised in t days then we have $Y_t = L - L_t$

$$\Rightarrow Y_t = L\left(1 - \frac{L_t}{L}\right)$$

$$\Rightarrow \frac{L_t}{L} = 1 - \frac{Y_t}{L} \quad \text{(II)}$$

equating eq^n ① & ②.

$$1 - \frac{Y_t}{L} = (10)^{-K_D \cdot t}$$

$$\frac{Y_t}{L} = 1 - (10)^{-K_D \cdot t}$$

$$\Rightarrow Y_t = L\left[1 - (10)^{-K_D \cdot t}\right] = BOD_t$$

The ultimate BOD which found out by putting $t = \infty$.

$$Y_U = L \times 1 = L = BOD_u$$

The deoxygenation constant K_D at a temp. other than 20°C can be found out by $K_D(T^\circ) = K_{D(20^\circ)}[1.047]^{T-20}$

f the period of incuvation is 10 days at 20°C in the relative conductivity and calculate the % of relative stability.

$$S = 100[1-(0.794)^{10}]$$

$$= 100 \times 0.9004$$

$$= 90.04\%$$

Disposal of waste water in sea water.

Sea water contains 20% less oxygen than river water and it contains large amount of dissolved solids. So sea water has less capacity to absorb sewage solid than that of freshwater. When sewage water mixed with sea water than precipitation of sewage solid occurs giving rise to milky appearance of sea water and form sludge bank and produce offensive H_2S gas.

The specific gravity of sea water is greater than that of sewage and sea water has low temp. than that of sewage. So, the lighter and warmer sewage will spread on the top surface of sea water. Which form a thin filling called sleck. So to avoid these all problem the sewage should be discharged in deep sea. (About 1.5 km from shore line) and at a minm depth of 3-5 m below the water level of sea.

The disposal point of sewage is decided taking into consideration the sea current, wind direction, velocity etc.

→ The outfall sewers should be placed on a rocky foundation to protect it from wave action and floating debris.

Disposal on Land :-

Disposal of sewage effluent for irrigation

The sewage effluent is dispose of by applying it on the land the persulating water either join water level or collected ~~below~~ by a system of underdrain is and the water is used to irrigate crops. which may increase the crop field to about 33%. The sewage contains, a lots of fertilising minerals like N, P, K etc. which are useful for the growth of crop.

When raw or partly treated sewage is applied on to the land than a part of it evaporates and remaining portion persulate through soil. while persulation the suspended particles are cut on the soil voids.

If proper erresion is maintained than the sewage in these pores are oxidised by aerobic decomposition. This happens for porous and permeable soil (sand & porous loams). If the soil is fine grained, heavy & sticky like clay or rock than the void spaces will be

clocked soon. then Nonaerobic decomposition occur with evolution of foul gases.
Application of too heavy load on sewage strong or too will result in quick ~~cond~~ formation of anaerobic condition.

Effluent irrigation method is applied in the following conditions:- (271)

Effluent irrigation –

In effluent irrigation or broad irrigation, the raw sattlleed sewage discharge on a vacant land with properly laid under drain. The effluent collected in these drains after getting filter through soil forces are disposed in to some natural ~~source~~ water sources without any treatment.

Sewage farming –

In sewage farming the effluent collected from under drains are used for irrigating crops. By various methods of irrigation.

Difference betn dilution method & land disposal method of sewage.

Sewage sickness -

When sewage is applied continuous on a piece of land, the soil pores get clogged with sewage matter. The time taken for such clogging depend upon type of soil and load of the sewage.

After clogging of soil pore, anaerob decomposition occur with evolution of foul gases like H_2S, CH_4, CO_2. This phenomenon of soil getting clogge is known as sewage sickness.

Remedial measure -

Dt. 9/4/19

Treatment of Sewage -

ypes of treatment process -

1) Priliminary treatment
2) Primary treatment
3) secondary or biological treatment
4) Final treatment

1) Priliminary -

In priliminary treatment various floating materials like dead animals, tree branches, papers, polythene etc. and also heavy settleable inorganic solid are separated out by screening grid chamber and skimming tank.

2) Primary -

It consists of removing large suspended organic solid for this purpose sedimentation tanks are used.

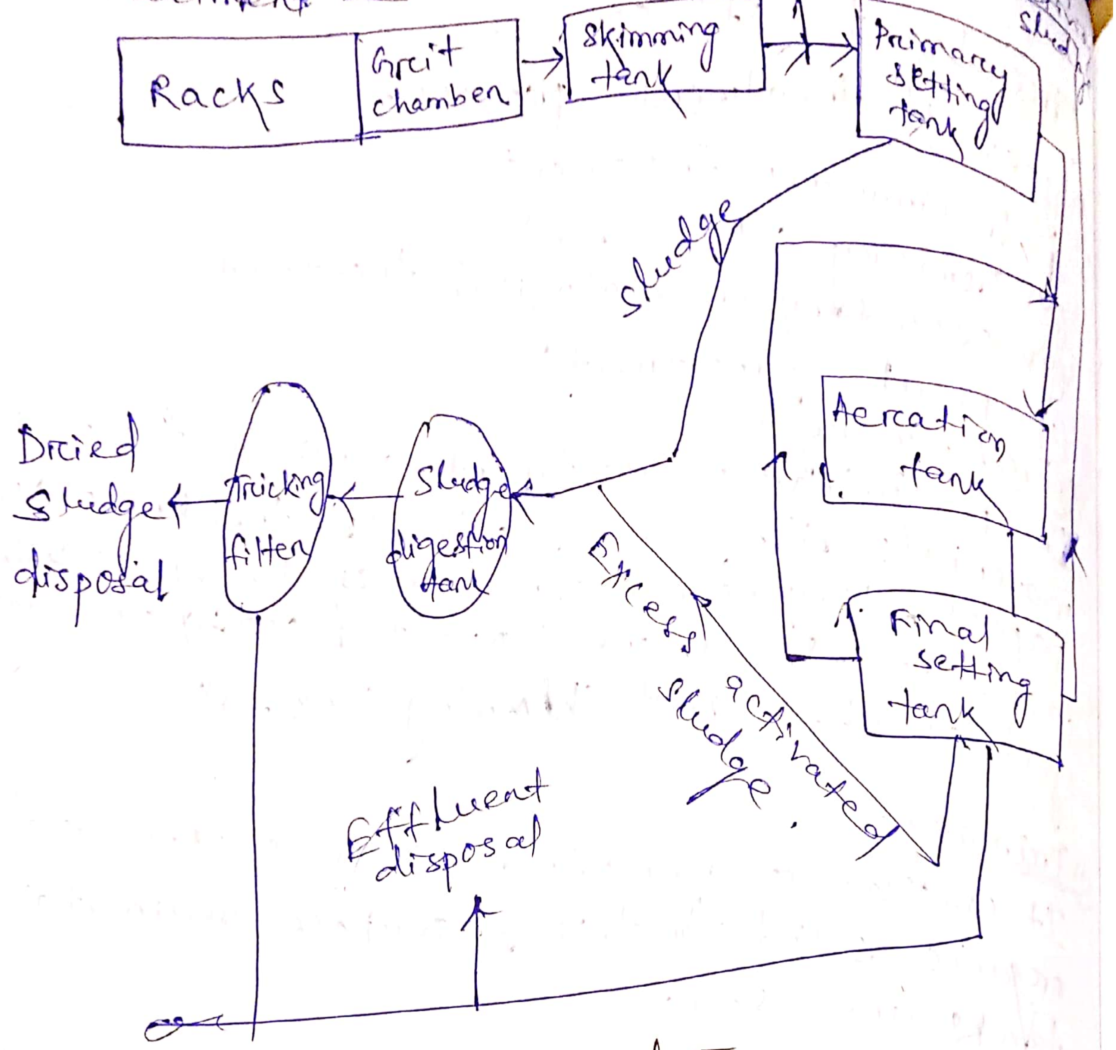
3) Secondary -

The effluent from primary sedimentation tank are treated with biological decomposition either by aerobic or anaerobic bacteria by filters, aeration tank, oxidation pond, anaerobic lagoons septic tank, Imhoff tanks etc,

4) Final treatment -

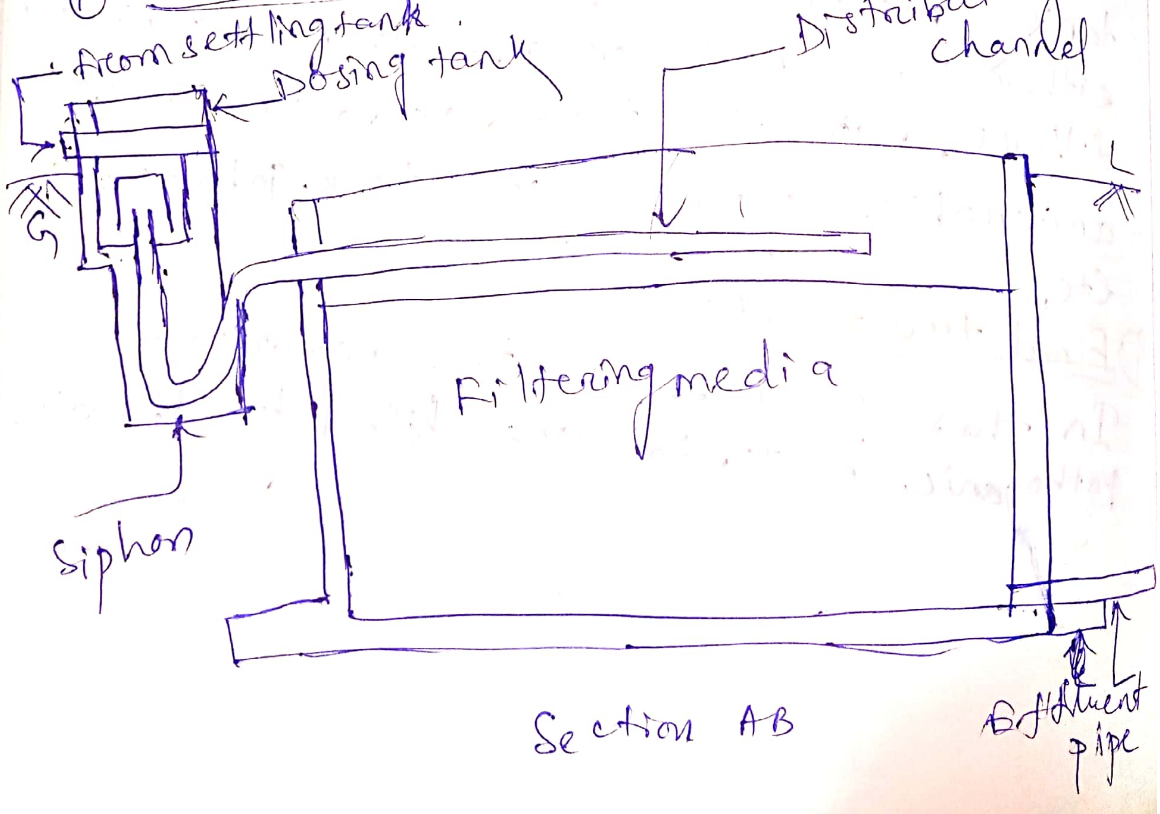
In this process all the remaining pathogenic bacteria are killed by chlorination.

* Flow diagram of conventional sewage treatment —

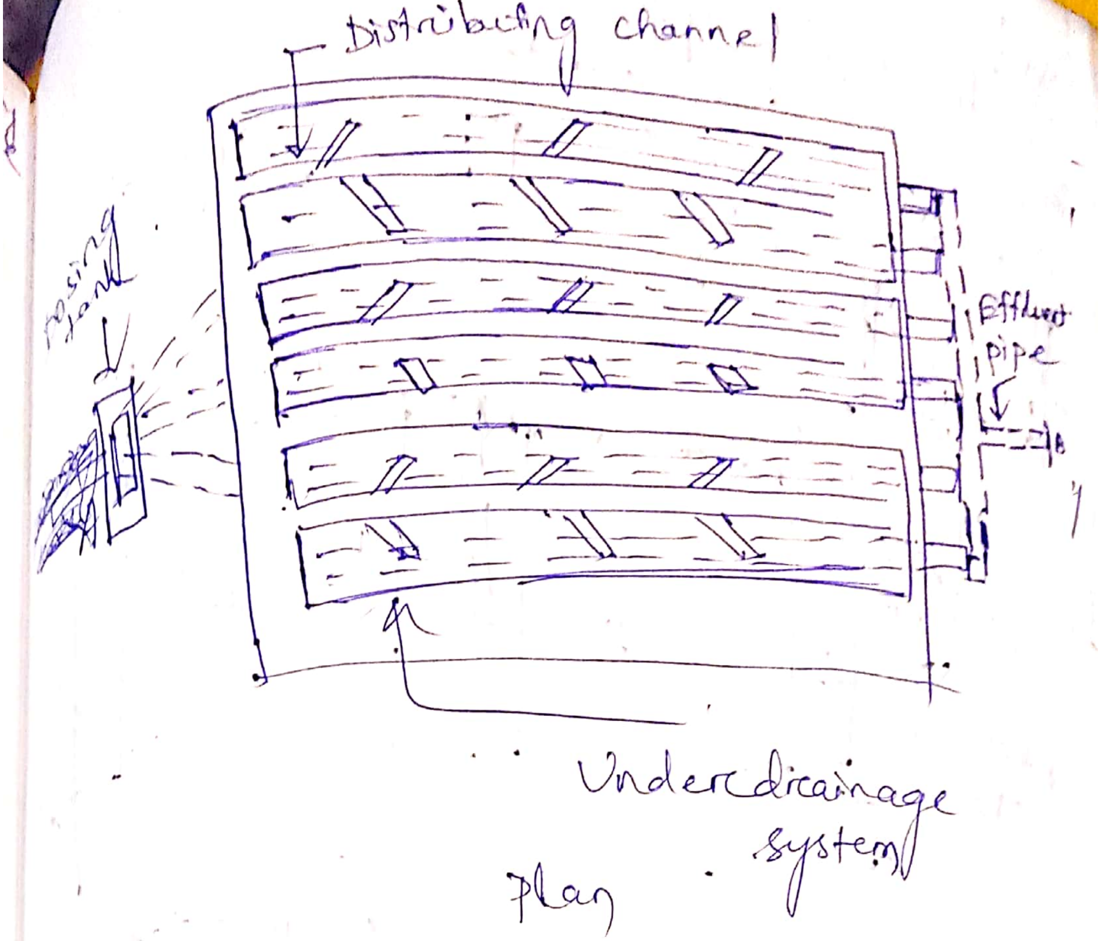


* Secondary treatment —

① Contact bed —



Section AB



Plan

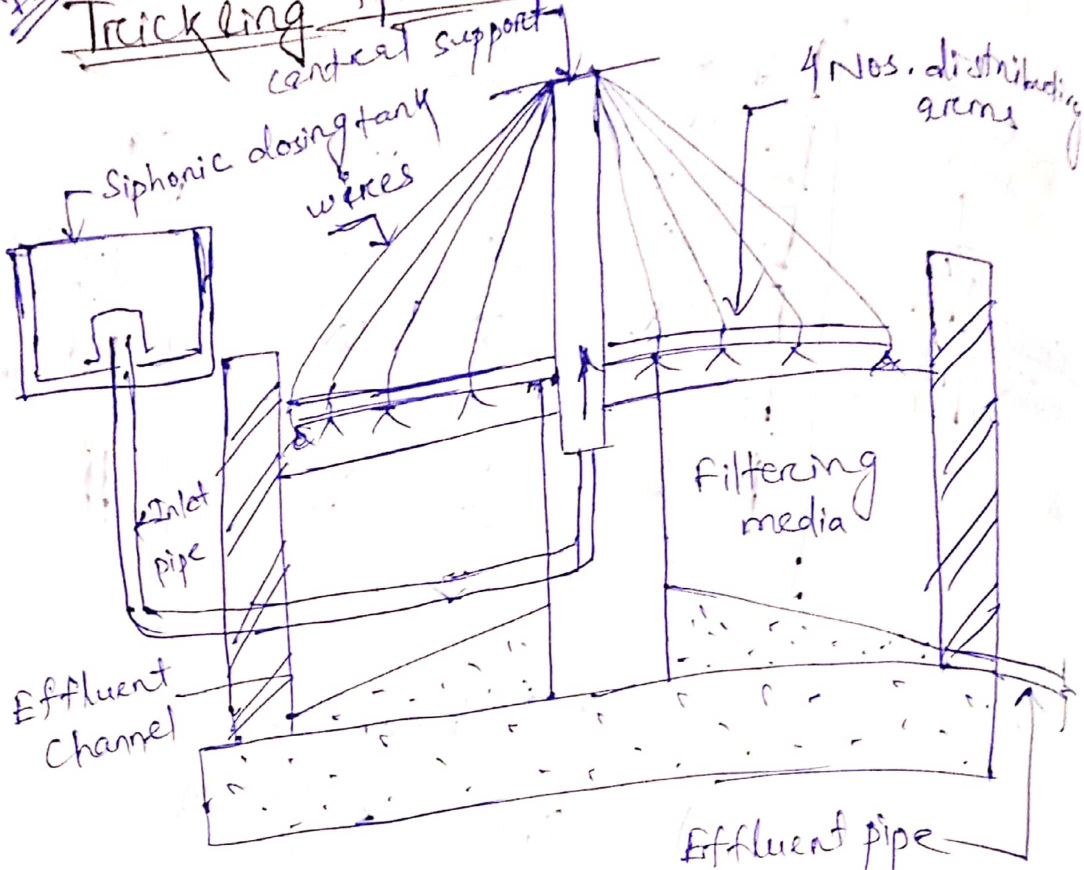
Contact bed.

Operation —

the sewage 1st of all allowed from dosing tank to fill the bed completely which takes along 1hr. Then the dosing tank supplyied is closed and the sewage is left over the contact bed for about 2hr. (1st contact period) After that the outlet valve is open and the sewage is removed slowly and bed remain at rest for a period of 4 to 6 hr. which is known as 2nd contact period. During this period the organic matter trapped in the voids get oxidised by aerobic bacteria by in the presence of free oxygen. The stabilised organic matters from the voids is finally washed down in the next empty water tank.

IMP

Trickling filter -



Circulate trickling filter

IMP

Activated sludge process -

The sludge which is made powerful by the process of aeration is known as activated sludge. It contains high content of oxygen and high no. of aerobic bacteria with property to oxidise the organic matter.

The activated sludge when mixed with raw sewage then the no. of micro organism or bacterias increases rapidly.

The activated sludge oxidise the organic substance rapidly. And it converts collidal matters to settable size rapidly..

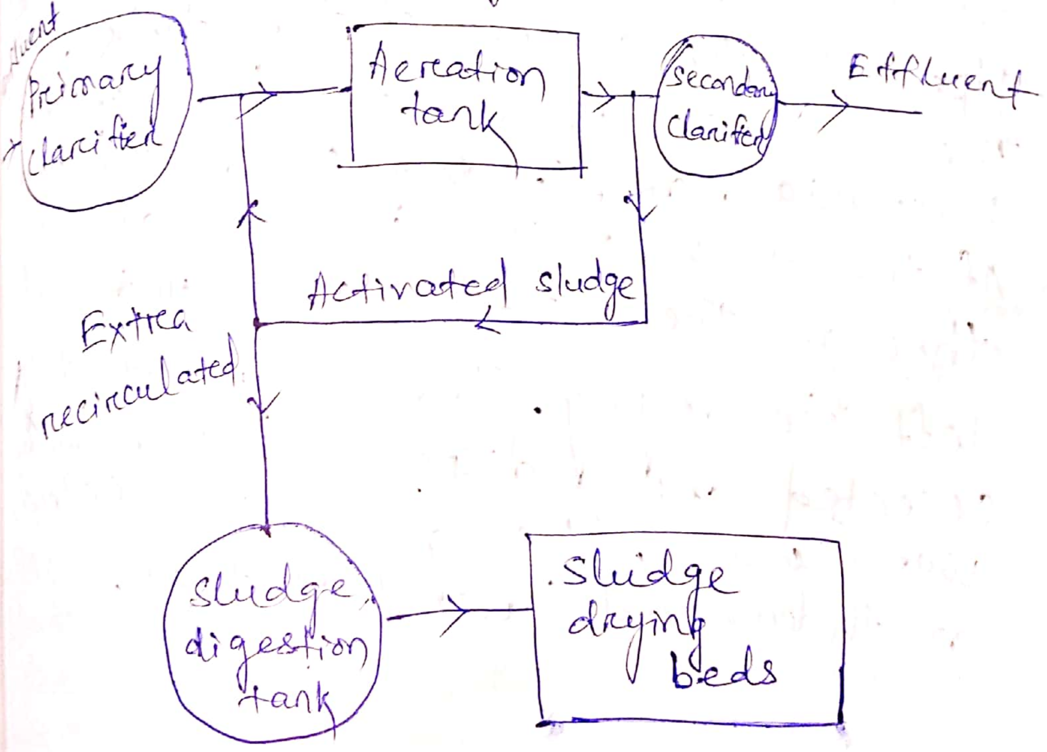
Operation -

Some portion of activated sludge settle at the bottom of ~~the~~ a ~~settling~~ secondary settling tank is recirculated and mixed with effluent of primary settling tank before they entering to aeration tank.

In aeration tank the effluent of primary settling tank and activated sludge have mixed rapidly with the air by some mechanical device.

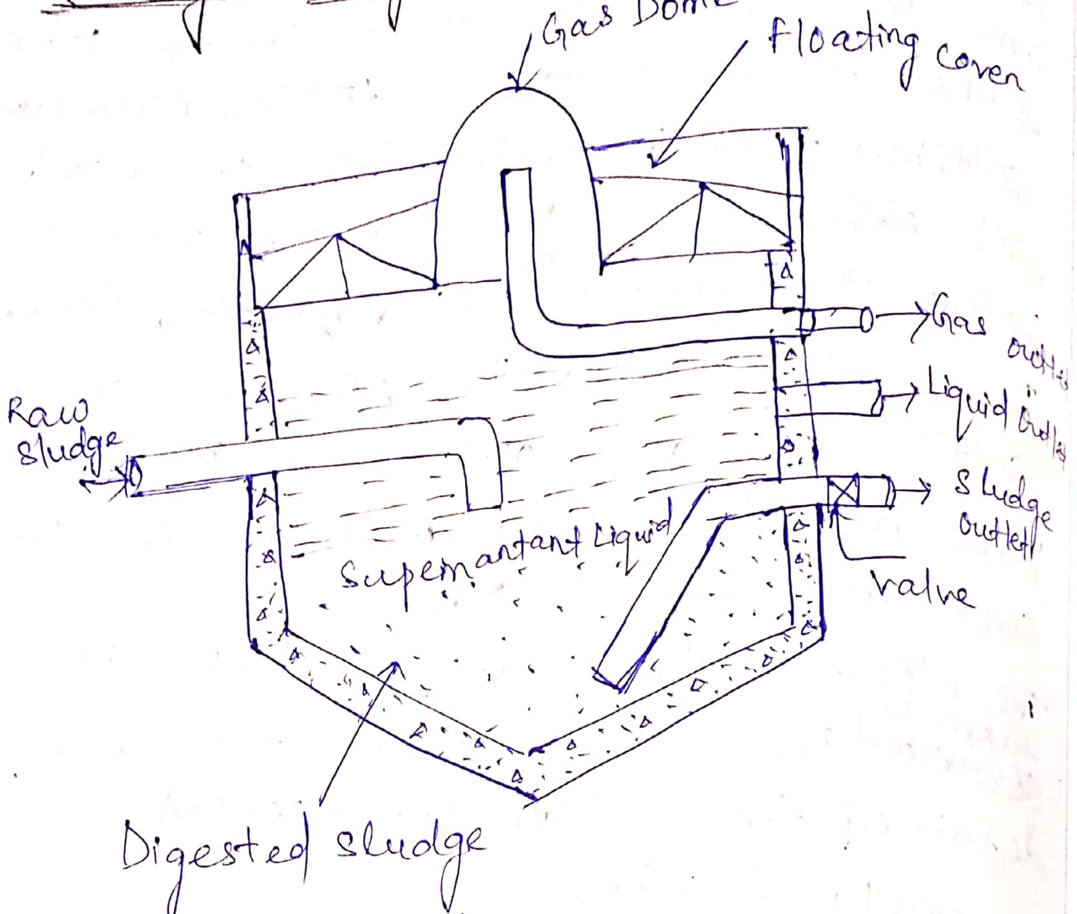
The effluent from aeration tank is taken to ~~aerated~~ secondary settling tank and detained for a specified period, generally of 1 hr.

Thus, the complete cycle is known as activated sludge.



Flow diagram of sludge process

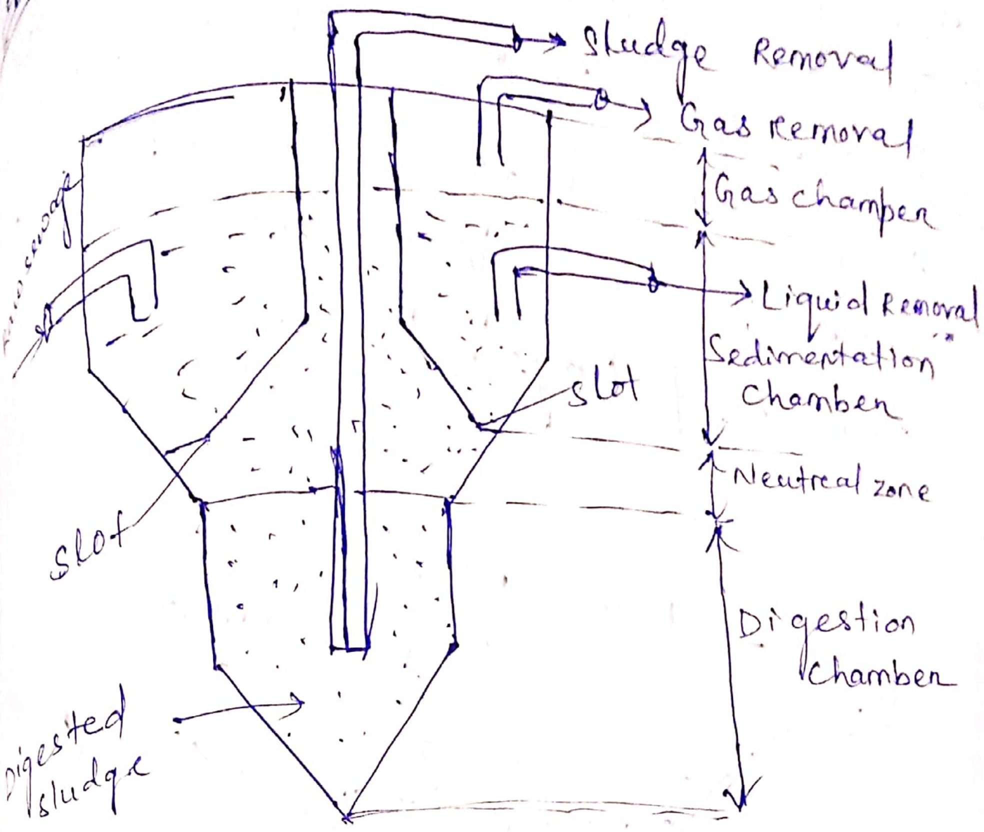
Sludge digestion tank -



working principle. -

The raw sludge from secondary qualifier enter the tank through the pipe at the centre of the tank. The sludge is digested by anaerobic bacteria and settled on the bottom of the tank which is with drawn through the outlet valve and left for drying. The supernatent liquid collected are disposed to the nearby water source. The gases are collected at th dome and used as fuel.

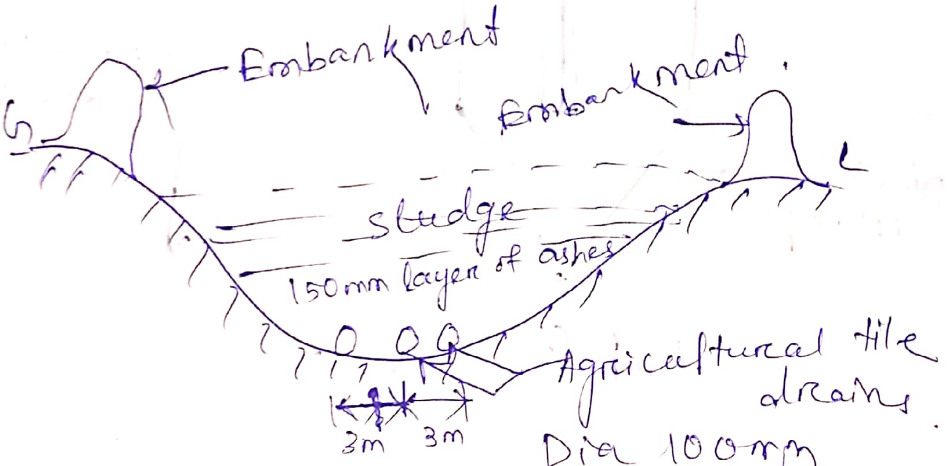
Imhoff tank -



Inhoff tank.

In Inhoff tank the sedimentation & digestion are carried out simultenenously. In sedimentation chamber the sewage contain in ~~every~~ heavy sludge from secondary clarifier ~~tank~~ is allowed to enter and detained for a specified period. The baffle walls helps in sedimentation process. the sludge settled down through the sludge and deposited in the digestion chamber. The neutral zone between the sludge and digestion chamber prevents the entry of digested sludge into the sedimentation chamber. The gas chamber collects the liberated gases and the gases are used as fuel. The digested sludge is withdrawn through the sludge removal pipe & taken to the drying bed.

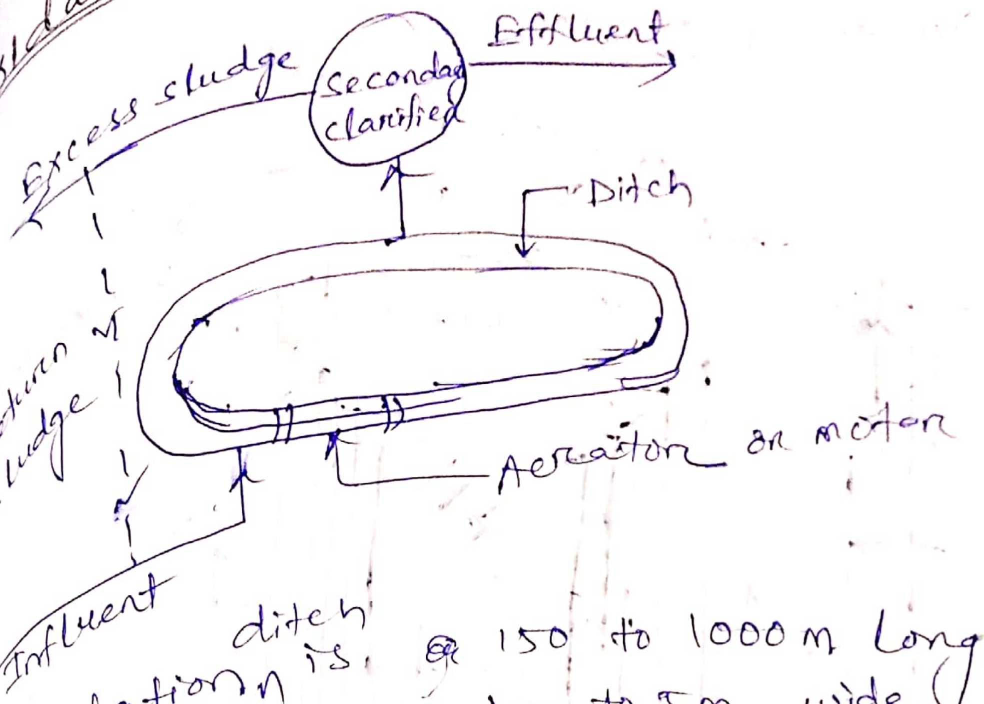
Aerated Lagoon:-



Lagoon.

It is an earthen basin of about 2.5 to 4m deep in which aeration of sewage takes place by mechanical aerators. The sewage is sent in the lagoon after passing through grit chamber, without giving any primary treatment. Aerated lagoon acts as a settling cum aeration tank, where detention period of 3 to 5 days is provided & 70 to 95% of BOD is removed. It is suitable for small town and its cost of construction is less.

Oxidation Ditch –



the oxidation ditch is 150 to 1000 m Long
1m to 5m wide
1 to 1.5 m deep

Here aeration of sewage takes place by mechanical aerator and solid contain of the sewage remains in suspension condition.

After aeration the sewage is allow to settle in the settling tank and the activated sludge is return back to the aeration unit. Here no primary treatment are given to the sewage. And a detension period of 3hr. is given to the tank.

Isolated treatment units –

Oxidation pond –