UNIT-IV TREATMENT OF WATER

1.Q. TREATMENT UNIT FLOW DIAGRAM

Water treatment includes many operations like Aeration, Flocculation, Sedimentation, Filtration, Softening, Chlorination and demineralization. Depending upon the quality of raw water and the quality of water desired. Several combinations of the above processes may be adopted as shown in the flow diagram.

I. When turbidity of water is less than 10 N.T.U

Raw Water → CHLORINATION → Treated water for supply

GROUND WATER

Raw Water → Sedimentation → Filtration → + Chlorination → Treated water for supply

SURFACE WATER

2.Q. THE LOCATION OF TRETMENT PLANT

One complete water treatment plant requires the following process starting from the source of water upto the distribution zone in order of sequence.

Sl.No.	Name of the unit	Purpose
1.	Intake work including pumping plant	Raw water from the source for treatment
2.	Plain sedimentation	To remove suspended impurities such as silt, clay, sand etc.
3.	Sedimentation with coagualtion	To remove the suspended matter
4.	Filtration	To remove microorgans and colloidal matter
5.	Water softening plant	To remove hardness of water
6.	Miscellaneous treatment plants	To remove dissolved gases, tastes and odours.
7.	Disinfection	To remove pathogenic bacteria
8.	Clear water reservoir	To store the treated water
9.	Pumps for pumping the water in service reservoirs	If town or city is situated at higher elevation then pumping is required.
10.	Elevated or underground service reservoir	For distribution of treated water.

3.Q The following points should be kept in mind while giving layout of any treatmentplant.

1. The W.T.P. should be located as near to the town so as to avoid the contamination.
2. All the units of plant should be located in order of sequence and flow from one unit to other by gravity.
3. All the units are arranged in such a way that minimum area is required so as to reduce the cost of construction.
4. Sufficient area should be reserved for the future expansion
5. Staff quarters and office should be provided near the treatment plants so that the operators can watch the plants easily.
6. The site of treatment plant should be very neat and give very good asthetic appearance.

SCREENING

Screens are fixed in the intake works or at the entrance of treatment plant so as to remove the floating matters as leaves, dead animals etc.

4.Q. TYPES OF SEDIMENTATIONS

It is the process in which the suspended solids are made to settle by gravity under still water conditions is called plain sedimentation.

PLAIN SEDIMENTATION :

By plain sedimentation the following are the advantages.

1. Plain sedimentation lightens the load on the subsequent process.
2. The operation of subsequent purification process can be controlled in better way.
3. The cost of cleaning the chemical coagulation basins is reduced.
4. No chemical is lost with sludge discharged from the plain settling basin.
5. Less quantity of chemicals are required in the subsequent treatment processes.

The amount of matter removed by sedimentation tank depends upon the factors.

1. Velocity of flow
2. size and shape of particles
3. Viscosity of water

The particles which do not change in size, shape or mass during settling are known as the discrete particles. The velocity of descrete particles with dia less than 0.1 mm is given by

$$V = 418 (S - S_1) d^2 \frac{(3T + 70)}{100} \quad \text{---------------- (1)}$$

Where V → Velocity of settlement in mm/sec

S → Specific gravity of the particles

S1 → Specific gravity of water

D → dia of the particle in mm

T → Temperature in °C

If the dia of the particle is greater than 0.1mm then the velocity is measured by

$$V = 418 (S - S_1) d \frac{(3T + 70)}{100} \quad \text{---------------- (2)}$$

In practice settling of the particles governed by the resultant of horizontal velocity of water and the verticle downward velocity of the particle. The path of the settling particle is as shown in Fig 5.2.

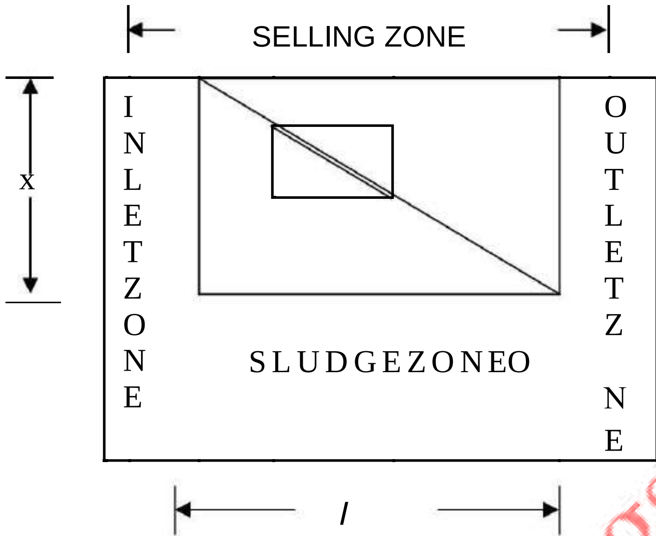


Fig 5.2 Settling of particles

DESIGN ASPECTS OF SEDIMENTATION TANKS

The design aspects of sedimentary tanks are

1. Velocity of flow
2. Capacity of tank
3. Inlet and outlet arrangements
4. Shapes of tanks
5. Miscellaneous considerations.

(1) **Velocity of flow:** The velocity of flow of water in sedimentation tanks should be sufficient enough to cause the hydraulic subsidence of suspended impurities. It should remain uniform throughout the tank and it is generally not allowed to exceed 150mm to 300mm per minute.

(2) **Capacity of tank:** capacity of tank is calculated by
i) detension period
ii) Overflow rate

(i) **Detension period:** The theoretical time taken by a particle of water to pass between entry and exit of a settling tank is known as the known as the detention period. The capacity of tank is calculated by

$V = Q \times T$ where $V \rightarrow$ Capacity of tank

$Q \rightarrow$ Discharge or rate of flow

$T \rightarrow$ Detension period in hours

The detention period depends on the quality of suspended impurities present in water. For plain sedimention tanks, the detension period is found to vary from 4 to 8 hours.

(ii) **Overflow Rate:** in this method it is assumed that the settlement of a particle at the bottom of the settlement of a particle at the bottom of the tank doesnot depend on the depth of tank and depends upon the surface area of the tank.

$$\text{Surface overflow rate, } V = \frac{D.Q}{C} = \frac{\cancel{D} \times Q}{L \times B \times \cancel{D}} = \frac{Q}{L \times B}$$

Where L → Length of tank
B → Breadth of tank
D → Depth of tank = Side water depth = S.W.D
C → Capacity of tank
T → Detention period
U → Discharge or rate of flow
V → Velocity of descend of a particle to the bottom of tank
= Surface overflow rate = S.O.R

(3) INLET AND OUTLET ARRANGEMENTS

The inlet is a device, which is provided to distribute the water inside a tank, and the outlet is a device, which is meant to collect outgoing water. These arrangements should be properly designed and located in a such a way that they do not form any obstruction or cause any disturbance to the flowing water.

SHAPES OF TANKS

Following are the three shapes of settling tank.

(i) Rectangular tanks with horizontal flow
(ii) Circular tanks with radial or spiral flow
(iii) Hopper bottom tanks with vertical flow

The following are the parameters for satisfactory performance.

1.	Detention period …..	3 to 4 hours for plain settling 2 to 21/2 hours for coagulant settling 1 to 11/2 hours for up flow type
2.	Overflow rate ………	30 – 40 m^3/m^2/day for horizontal flow 40-50m^3/m^2/day for up flow
3.	Velocity of flow……..	0.5 to 1.0 cm/sec
4.	Weir loading………..	300m^3/m/day
5.	L:B …………………..	1:3 to 1:4
	Breadth of tank……..	(10 to 12m) to 30 to 50m
6.	Depth of tank……….	21/2 – 4m
7.	Dia of circular tank….	upto 60m
8.	Solids removal efficiency…..	50%
9.	Turbidity of water after sedimentation – 15 to 20 N.T.U.	
10.	Inlet and Oulet zones……….	0.75 to 1.0m
11.	Free board……………………	0.5m
12.	Sludge Zone………………….	0.5m

5.Q. SEDIMENTATION AIDED WITH COAGULATION

When water contains fine clay and colloidal impurities which are electrically charged are continually in motion and never settle down due to gravitational force. Certain chemicals are added to the water so as to remove such impurities which are not removed by plain sedimentation. The chemical form insoluble, gelatinous, flocculent precipitate absorbs and entagle very fine suspended matter and colloidal impurities during its formation and descent through water.

The following are the mostly used Coagulants with normal dose and PH values required for best floc formation as shown in Table

Sl.No.	Coagulant	PH Range	Dosage mg/l
1.	Aluminium sulphate $Al_2(SO_4)_3$, 18 H_2O	5.5 – 8.0	5 – 85
2.	Sodium Aluminate, $Na_2Al_2O_4$	5.5 – 8.0	3.4 – 34
3.	Ferric Chloride ($Fecl_3$)	5.5 – 11.0	8.5 – 51
4.	Ferric Sulphate Fe_2 $(SO_4)_3$	5.5 – 11.0	8.5 – 51
5.	Ferric Sulphate $FeSO_47H_2O$	5.5 – 11.0	8.5 - 51

Coagulants are chosen depending upon the PH of water. Alum or Aluminium sulphate is normally used in all treatment plants because of the low cost and ease of storage as solid crystals over long periods.

The dosage of coagulants, which should be added to the water, depends upon kind of coagulant, turbidity of water, colour of water, PH of water, temperature of water and temperature of water and mixing & flocculation time. The optimum dose of coagulant required for a water treatment plant is determined by a Jar test as shown in Fig

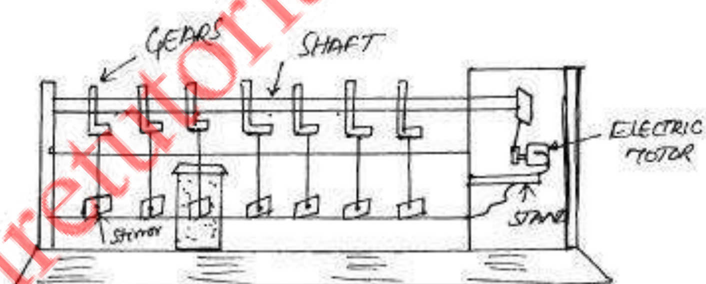


Fig Jar Test Apparatus

For starting the experiment first of all the sample of water is taken in every jar and added the coagulant in a jar in varying amounts. The quantity of coagulant added in each jar is noted. Then with the help of electric motar all the paddles are rotated at a speed of 30-40 R.P.M. for about 10 minutes. After this the speed is reduced and paddles are rotated for about 20-30 minutes. The rotation of paddles is stopped and the floc formed in each Jar is noted and is allowed to settle. The dose of coagulant which gives the best floc is the optimum dose of coagulants.

The coagulants may be fed or allowed to enter either in powder form called dry feeding or in solution form called wet feeding. The mixing of coagulant with the water to form the floc by the following methods.

1. Centrifugal pump
2. compressed air
3. hydraulic jump
4. mixing channel
5. mixing basins with buffle walls
6. Mixing basins with mechanical means

Now a days some firms manufacture combined unit comprising of feeding, mixing, flocculator and clarifier device. The Fig shows used for sedimentation with coagulation.

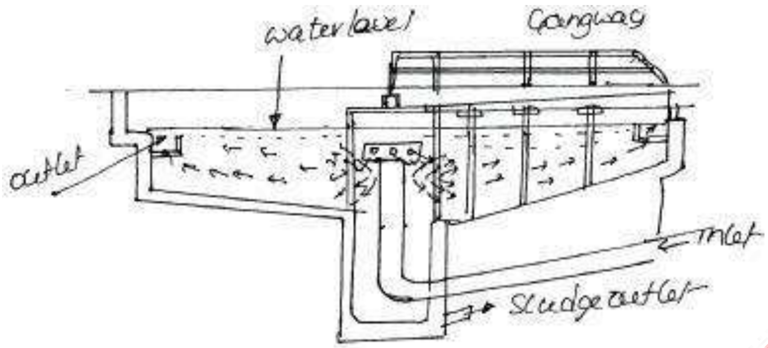


Fig Sedimention with Caogulation

Water enters in this tank through central inlet pipe placed inside the deflector box. The deflector box deflects the water downwards and then it goes out through the holes provided sides of the deflector box. The water flows radially from the deflector box towards the circumference of the tank, where outlet is provided on the full periphery as shown in the Fig. All the suspended particles along with floc settle down on the slopy floor and clear water goes through outlet. The sludge is removed by scrapper which continuously moves around the floor with very small velocity.

Disinfection and repainting is to be carried out once in ayear before mansoon. Sludge pipes are to be flushed and kept clean. Bleaching powder may be used to control the growth of algae on the weirs. Scraper mechanism should be oiled and greased periodically.

FILTRATION

The process of passing the water through beds of sand or other granular materials is known as filtration. For removing bacteria, colour, taste, odours and producing clear and sparkling water, filters are used by sand filtration 95 to 98% suspended impurities are removed.

THEORY OF FILTRATION

The following are the mechanisms of filtration

1. Mechanical straining – Mechanical straining of suspended particles in the sand pores.
2. Sedimentation – Absorption of colloidal and dissolved inorganic matter in the surface of sand grains in a thin film
3. Electrolytic action – The electrolytic charges on the surface of the sand particles, which opposite to that of charges of the impurities are responsible for binding them to sand particles.
4. Biological Action – Biological action due to the development of a film of microorganisms layer on the top of filter media, which absorb organic impurities.

Filtration is carries out in three types of filters

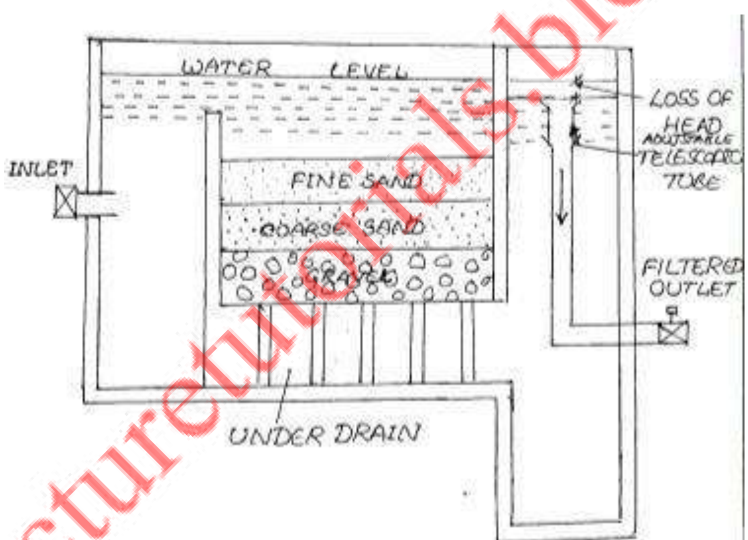
1. Slow sand filter
2. Rapid sand filter } Gravity filters
3. Pressure filter

6.Q. EXPALIN SLOW SAND FILTER WITH NET FIGURE

Slow sand filters are best suited for the filtration of water for small towns. The sand used for the filtration is specified by the effective size and uniformity coefficient . The effective size, D_{10}, which is the sieve in millimeters that permits 10% sand by weight to pass. The uniformity coefficient is calculated by the ratio of D_{60} and D_{10}.

CONSTRUCTION

Slow sand filter is made up of a top layer of fine sand of effective size 0.2. to 0.3mm and uniformity coefficient 2 to 3 . The thickness of the layer may be 75 to 90 cm. Below the fine sand layer, a layer of coarse sand of such size whose voids do not permit the fine sand to pass through it. The thickness of this layer may be 30cm. The lowermost layer is a graded gravel of size 2 to 45mm and thickness is about 20 to 30cm. The gravel is laid in layers such that the smallest sizes are at the top. The gravel layer is the retains for the coarse sand layer and is laid over the network of open jointed clay pipe or concrete pipes called under drainage. Water collected by the under drainage is passed into the out chamber



Slow Sand Filter

OPERATION

The water from sedimentation tanks enters the slow sand filter through a submersible inlet as shown in fig 5.3 This water is uniformily spread over a sand bed without causing any disturbances. The water passes through the filter media at an average rate of 2.4 to 3.6 m^3/m^2/day. This rate of filtration is continued until the difference between the water level on the filter and in the inlet chamber is slightly less than the depth of water above the sand. The difference of water above the sand bed and in the outlet chamber is called the loss of head.

During filtration as the filter media gets clogged due to the impurities, which stay in the pores, the resistance to the passage of water and loss of head also increases. When the loss of head reaches 60cm, filtration is stopped and about 2 to 3 cms from the top of bed is scrapped and replaced with clean sand before putting back into service to the filter. The scrapped sand is washed with the water, dried and stored for return to the filter at the time of the next washing . The filter can run for 6 to 8 weeks before it becomes necessary to replace the sand layer.

USES

The slow sand filters are effective in removal of 98 to 99% of bacteria of raw water and completely all suspended impurities and turbidity is reduced to 1 N.T.U. Slow sand filters also removes odours, tastes and colours from the water but not pathogenic bacteria which requires disinfection to safeguard against water-borne diseases. The slow sand filters requires large area for their construction and high initial cost for establishment. The rate of filtration is also very slow.

MAINTENANCE

The algae growth on the overflow weir should be stopped. Rate of filtration should be maintained constant and free from fluctuation. Filter head indicator should be in good working condition. Trees around the plant should be controlled to avoid bird droppings on the filter bed, No coagulant should be used before slow sand filtration since the floc will clog the bed quickly.

6.Q. EXPALIN RAPID SAND FILTER WITH FIGURE

Rapid sand filter are replacing the slow sand filters because of high rate of filtration ranging from 100 to 150m^3/m^2/day and small area of filter required. The main features of rapid sand filter are as follows.

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Effective size of sand	-	0.45 to 0.70mm
Uniformity coefficient of sand	-	1.3 to 1.7
Depth of sand	-	60 to 75cm
Filter gravel	-	2 to 50mm size (Increase size towards bottom)
Depth of gravel	-	45cm
Depth of water over sand during filtration	-	1 to 2m
Overall depth of filter including 0.5m free board	-	2.6m
Area of single filter unit	-	100m^2 in two parts of each 50m^2
Loss of head	-	Max 1.8 to 2.0m
Turbidity of filtered water	-	1 NTU

OPERATION

The water from coagulation sedimentation tank enters the filter unit through inlet pipe and uniformily distributed on the whole sand bed. Water after passing through the sand bed is collected through the under drainage system in the filtered water well. The outlet chamber in this filter is also equipped with filter rate controller. In the beginning the loss of head is very small. But as the bed gets clogged, the loss of head increases and the rate of filtration becomes very low. Therefore the filter bed requires its washing.

WASHING OF FILTER

Washing of filter done by the back flow of water through the sand bed as shown in Fig

First the value 'A' is closed and the water is drained out from the filter leaving a few centimeter depth of water on the top of sand bed. Keeping all values closed the compressed air is passed through the separate pipe system for 2-3 minutes, which agitates the sand bed and stirrer it well causing the loosening of dirt, clay etc. inside the sand bed. Now value 'C' and 'B' are opened gradually, the wash water tank, rises through the laterals, the strainers gravel and sand bed. Due to back flow of water the sand expands and all the impurities are carried away with the wash water to the drains through the channels, which are kept for this purpose.

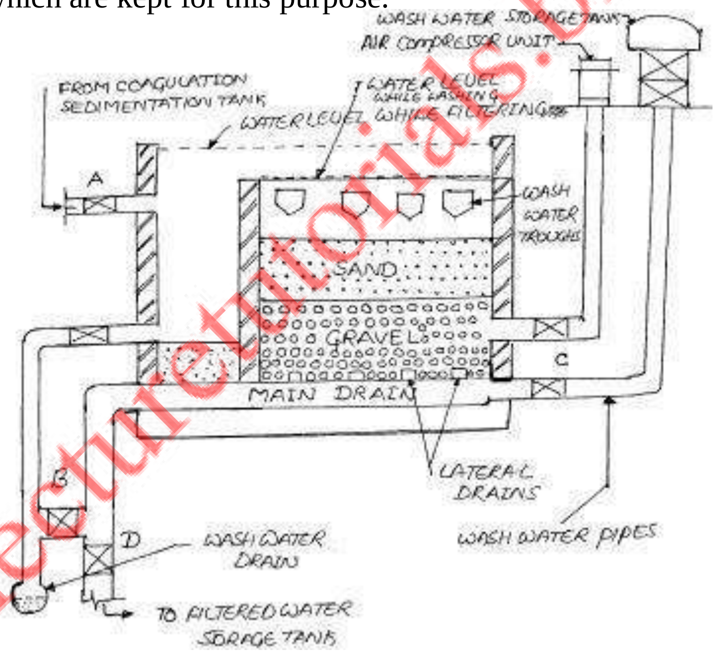


Fig Rapid Sand Filter

CONSTRUCTION

Rapid sand filter consists of the following five parts

1. Enclosure tank – A water tight tank is constructed either masony or concrete
2. Under drainage system – may be perforated pipe system or pipe and stracher system
3. Base material – gravel should free from clay, dust, silt and vegetable matter. Should be durable, hard, round and strong and depth 40cm.
4. Filter media of sand – The depth of sand 60 to 75cm

5.Inlet and Out let

7.Q. Comparision of slow sand filter and rapid sand filter

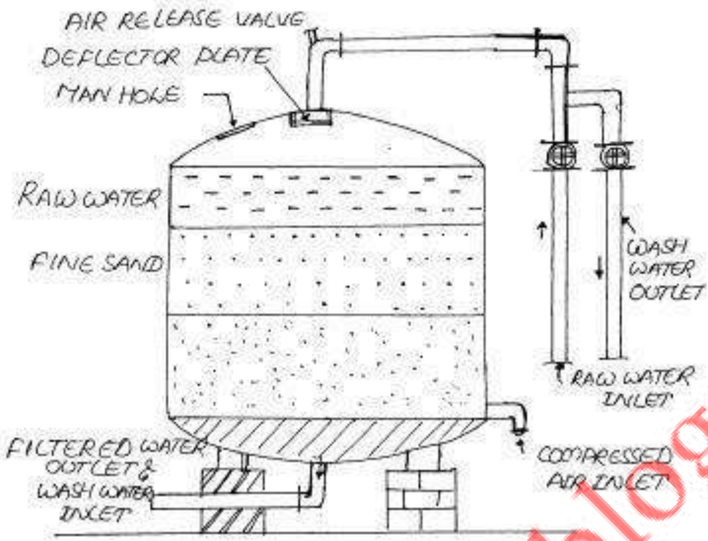
Sl.No.	ITEM	S.S.F	R.S.F
1.	Area	Need very large area	Needs small area
2.	Raw Water Turbidity	Not more than 30 NTU	Not more than 10NTU hence needs coagulation
3.	Sand Media	Effective size 0.2 to 0.3 mm uniformity coefficient 2 to 3 single layer of uniform size	Effective size 0.45 to 0.7 mm uniformity coefficient 1.3 to 1.7 multiple graded layers of sand.
4.	Rate of Filtration	2.4 to 3.6m^3/m^2/day	100-150 m^3/m^2/day
5.	Loss of Head	0.6m to 0.7 m	1.8m to 2.0m
6.	Supervision	No skilled supervision is required	Skilled supervision is required
7.	Cleaning of Filter	Scraping of 21/2cm thick layer washing and replacing. Cleaning interval that is replacement of sand at 1 to 2 months.	Back wash with clean water under pressure to detach the dirt on the sand. Backwashing daily or on alternate days.
8.	Efficiency	Bacterial removal, taste, odour, colour and turbidity removal.	There is no removal of bacteria. Removal colour taste, odour and turbidity is good.

8.Q EXPALIN THE PRESSURE FILTER

Pressure filter is type of rapid sand filter in a closed water tight cylinder through which the water passes through the sand bed under pressure. All the operations of the filter is similar to rapid gravity filter, expect that the coagulated water is directly applied to the filter without mixing and flocculation. These filters are used for industrial plants but these are not economical on large scale.

Pressure filters may be vertical pressure filter and horizontal pressure filter. The Fig shows vertical pressure filter. Backwash is carried by reversing the flow with values. The rate of flow is 120 to 300m^3/m^2/day.

Figure Vertical Pressure Filter



ADVANTAGES

1. It is a compact and automatic operation
2. These are ideal for small estates and small water works
3. These filters requires small area for installation
4. Small number of fittings are required in these filters
5. Fitered water comes out under pressure no further pumping is required.
6. No sedimentation and coagulant tanks are required with these units.

DISADVATAGES

1. Due to heavy cost on treatment , they cannot be used for treatment large quantity of water at water works
2. Proper quality control and inspection is not possible because of closed tank
3. The efficiency of removal of bacteria & turbidity is poor.
4. Change of filter media, gravel and repair of drainage system is difficult.