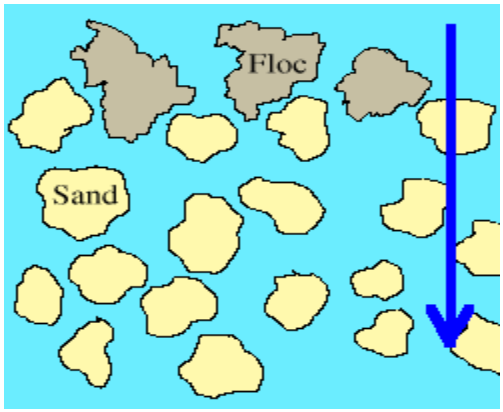
Filtration

Purpose of filtration :

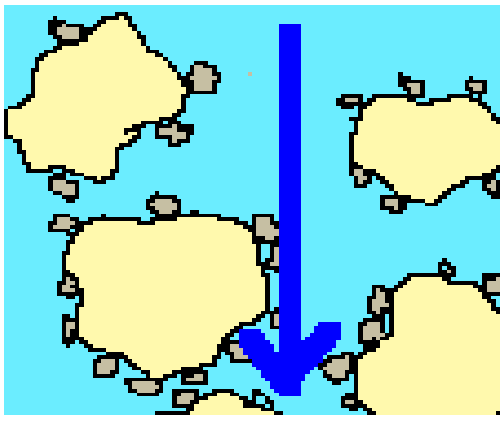
Removal of remaining 4% of suspended solids.
Removal of odor, color and taste.
Removal of iron and manganese.
Removal of 90 % of bacteria.

Mechanism of filtration :

1- Straining action: strain particles that has a big size on the sand surface.



2- Sedimentation action: sediment the small particles in the gaps between the sand particles.
3- Adsorption action: the gelatinous layer around the sand particles attracts the suspended solids.



4- Biological action: the bacteria which grow in the gelatinous layer around the sand particles decompose the organic matter.
The red color due to iron removed in rapid sand filter by biological action.
Ferrous oxide (FeO) $\longrightarrow$ Ferric Oxide (Fe2O3)

5- Electrical action: particles with different electrical signs attract, so the suspended solids attract to sand surface of different electrical sign.

Factors affecting filtration :

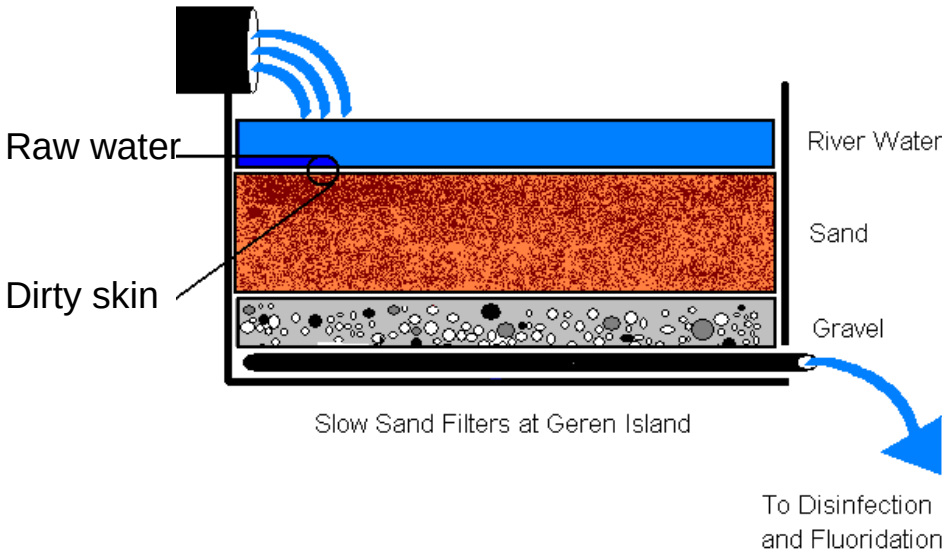
1- Thickness of sand layer.
2- depth of water above the sand layer.
3- Characteristics of sand.
4- Preparation of water to be filtered.

Types of filters:

1- Slow sand filter (gravity type)
2- Rapid sand filter (gravity type)

Slow sand filter

Slow sand filters used in case of plain sedimentation.
The filtration action is at the surface of the sand layer.



A schematic diagrams of slow sand filter

slow sand filter with water layer

Clean slow sand filter without water layer

Under drainage system of slow sand filter

Removal of dirty skin layer

Design criteria:

1- Qd = Qmax.monthly
= Qave x 1.5
2- Rate of filtration = 3 - 5 $m^3/m^2/day$
3- Area of filtration = 1000 - 2000 m^2
4- Thickness of sand layer = 70 - 140 cm of diameter
0.25 - 0.35 mm
5- Thickness of gravel layer = 70 - 140 cm
6- Inlet velocity = 0.5 - 0.7 m/s
7- Velocity in under drainage system not > 0.6 m/s

Advantages of slow sand filter :

1- good quality of water with respect to the rapid sand filter outlet water
2- Save the quantity of water used in the filter washing
3- Save the energy used in washing filter
4- There is no problem in getting rid of the polluted water of washing
5- low construction fees
6- Easy to design and to operate

7- dose not need trained labor
8- does not need any chemicals

Disadvantages of slow sand filter :

1- The outlet water discharge is too low compared to the rapid sand filter
2- Needs a large area.

Example:

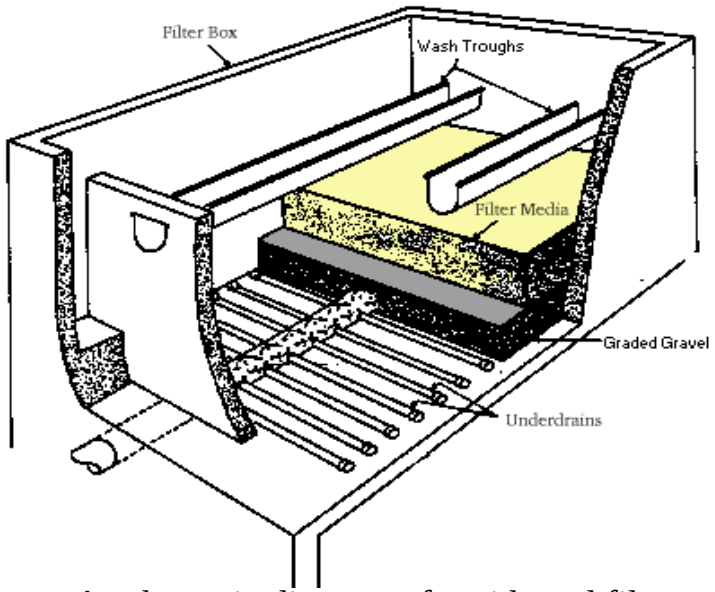
It is required to design slow sand filter for a city of daily out put 60000 m3.

Solution:

Qd = 60000 m^3 /d
Rate of filtration = 3 – 5 m^3 /m^2 /d take it 5 m^3 /m^2 /d
Area of filters = Q_d / R.O.F
Area of filters = 60000 / 5 = 12000 m^2
Area of one filter = 1000 – 2000 m^2
N0. of filters = 12000 / 1000 = 12 filter + 1 reserve

Rapid sand filter

The filtration action is through the sand layer.
Requirement of chemical coagulant is essential.
Cleaning of filter by using water under pressure in up word direction.
In rapid sand filter the thickness of sand layer decreases, the height of water above the sand layer increases and the size of sand particles increase.



A schematic diagram of rapid sand filter

Operation of rapid sand filter:

1- Start of operation stage

Open V5 and V4 to let the water go from the bottom to the upper layers of sand to get rid of air between the sand particles.

2- Maturation stage

Close V5 and V4 and open V1and V6 for 5 – 15 minutes to create the glutinous layer around the sand particles.

3- Filtration stage

Close V6 and open V1 and V2 for 12 – 36 hours.

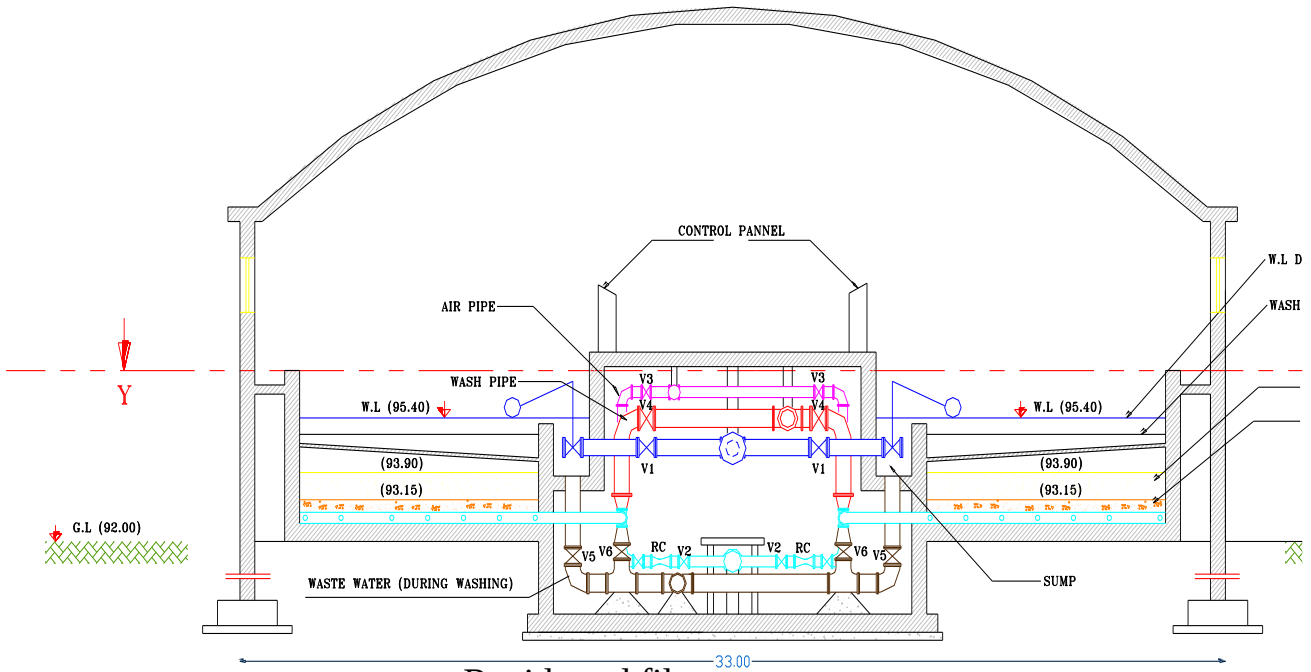
4- Washing stage

Close V1 and V2 and open V3 for 4 – 6 minutes, and open V5 and V4 for 6 minutes. The washing period is 8 – 10 minutes or 15 to 20 minutes in case of using air.

- At the start of washing empty the water in the sump and the under drainage system by opening V5 and V6 let the water height 10 cm above the sand surface.
- Close all the valves and open V3 for entrance of compressed air.
- V5 is opened in all washing stages.
- Open V1 and V5 all other valves closed. Effluent sometimes filtered to waste for a few minutes after filter has been washed to condition the filter before it is put into serves.

Rapid Sand Filter

Rapid Sand Filter
Back-wash and Air-wash type



Rapid sand filter

V1	Inlet valve
V2	Outlet valve
V3	Air valve
V4	Wash valve
V5	Waste valve
V6	Preparing valve
RC	Rate control valve

Design criteria:

1- Q_d = Qmax.monthly x 1.1

2- Rate of filtration = (120 - 180) $m^3/m^2/day$

3- Area of filter = (40 - 60) m^2

4- Thickness of gravel layer = (30 - 60) cm

5- Thickness of sand layer = (50 - 70) cm size of sand (0.6 - 1.5) mm

6- Area of filters = Qd / rate of filtration

If 5 < n < 30 ◊ take 2 filters for wash

if n ⩽ 5 ◊ take 1 filter for wash

if n ⩾ 30 ◊ take 4 filters for wash

7- L : B = 1 : 1.25

Example:

It is required to design rapid sand filters for a city of daily out put 60000 m^3.

Solution:

Q_d = 60000 x 1.1 = 66000 m^3 /d

Rate of filtration = 120 – 180 m^3 /m^2 /d take it 150 m^3 /m^2 /d

Area of filters = Qd / R.O.F

Area of one filter = 40 – 60 m^2 take it 50 m^2

Area of filters = 66000 / 150 = 440 m^2

N0. of filters = 440 / 50 = 8.8 ~ 8 filters + 2 for wash

Area of filter = 440 / 8 = 55 m

If L = 8 m B = 6.88 m

R.O.W = 5 X R.O.F

= 5 x 150 = 750 m^3 /m^2 /d

Assume time of washing 10 minutes

Amount of washing water = R.O.W x n x A (of one filter) x time of wash

= 750 x 8 x 55 x (10/24x60)

= 2291.67 m^3 /m^2 /d