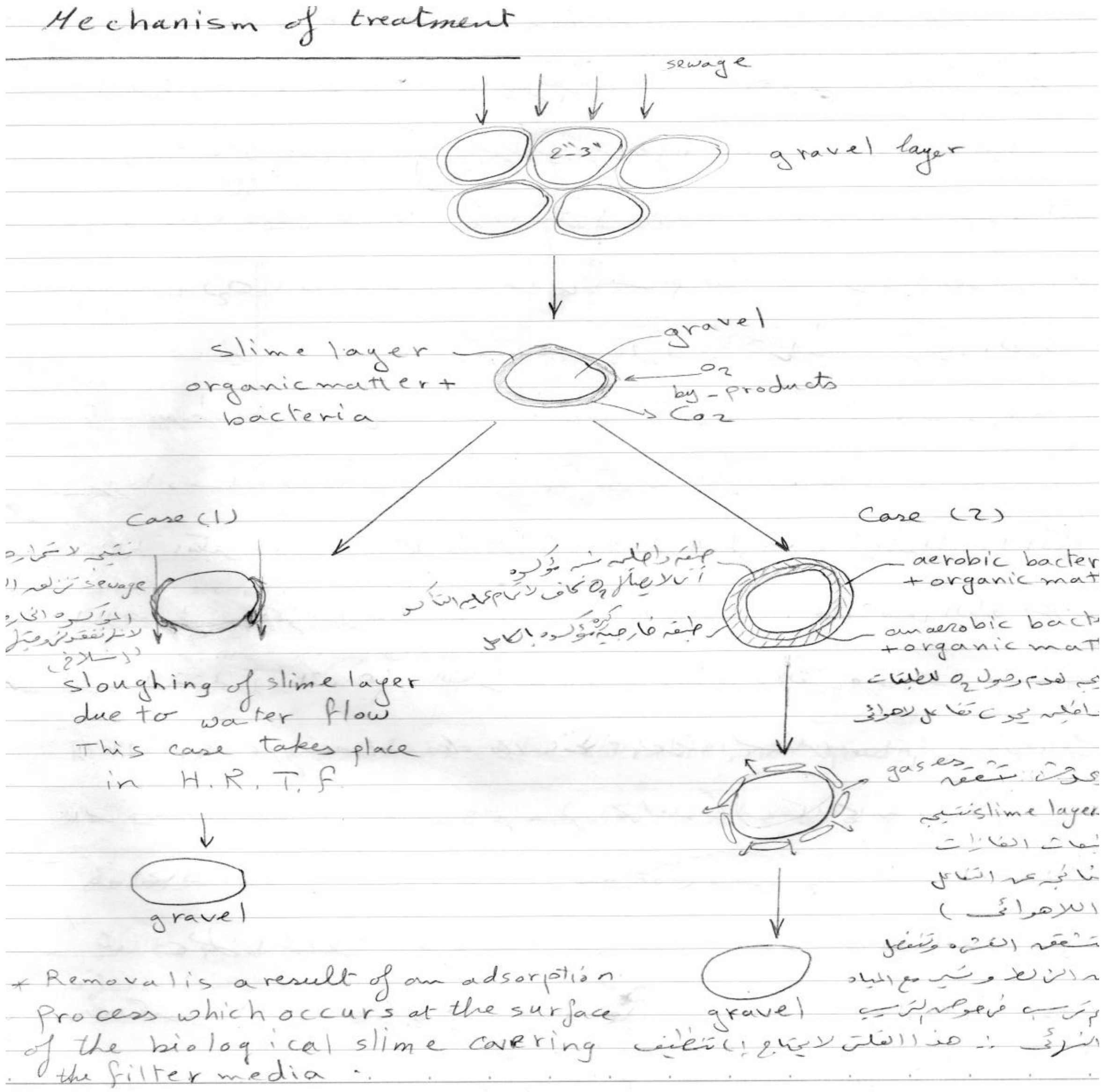
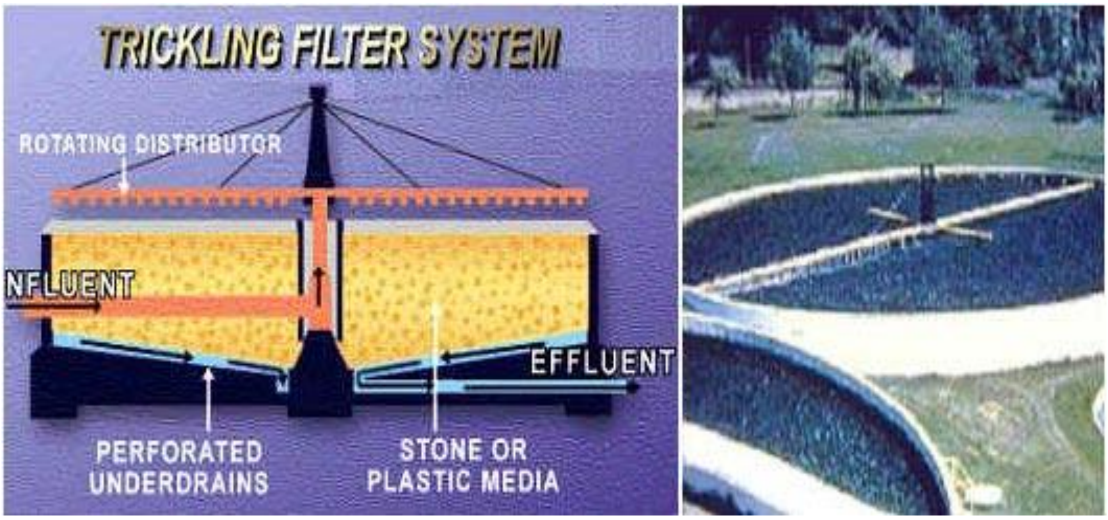
Trickling filters
Attached growth reactor

In this type of reactor , reaction between organic matter and bacteria takes place on the surface of inert media (gravel, crushed stone …ext) in the presence of oxygen.

Purpose:
Stabilize organic matter and make it satiable.





A schematic diagram of standard rate trickling filter

Trickling filters

<u>Filter media used:</u>

- Gravel, crushed stone, plastic …..ext.

- The filter media should be durable, not graded with high surface area to allow wastewater to pass down words, and air to pass up words.
- The filter media must not be expensive.

<u>Under drainage system:</u>

The under drainage system allows the passage of both wastewater and air.

Distribution system:
Distribute the wastewater uniformly on the surface of the trickling filter. Distance between nozzles decreases when move towards the outer perimeter to maintained uniform distribution of wastewater over the surface area of the filter.

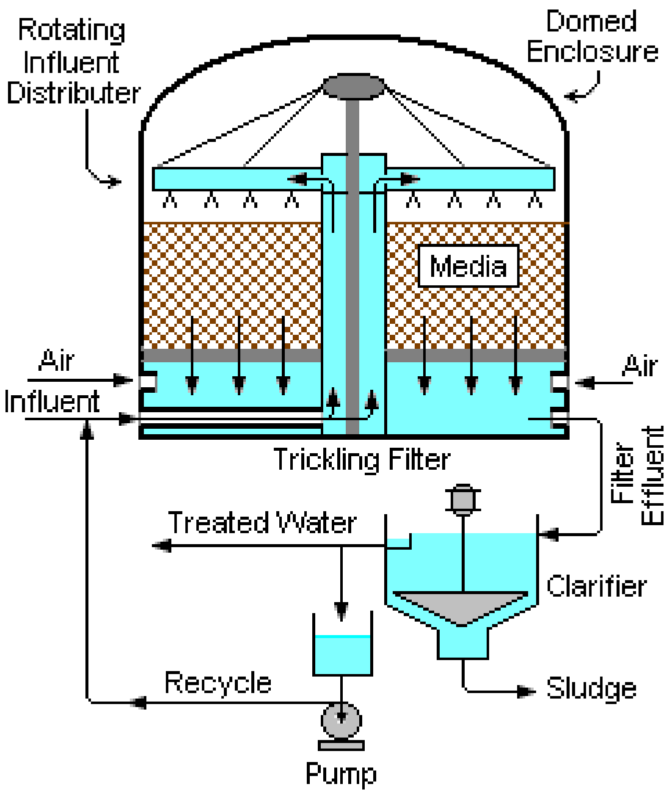
Types of trickling filters:
1- Standard rate trickling filter.
2- High rate trickling filter.

1- Standard rate trickling filter
Advantages :
1- high efficiency : BOD & suspended solid removal > 95 %
2- low operation & maintenance cost
3- No skill labor is required

Disadvantages :
1- Rate of filtration is low 1 - 4 m^3/m^2/day.
2- Large area is required.
3- Construction cost is high.
4- Breeding place for flies.

Advantages of dosing chamber:
- Control the quantity of sewage required to make complete rotation by the arms.
- Make the flow discontinuous to give the chance for the reaction between aerobic bacteria and organic matter to take place.
- Assure the continuity of arms rotation

2- High rate trickling filter
Advantages of recirculation:
1-Rreturn oxygen with wastewater.
2- Return active bacteria to increase reaction rate which decrease the required area for the increase of the allowable load.
3- Decrease the concentration of BOD on filter.
4- Achieve the plant working day by night.
5- Prevent the growth of fly around the filter.
6- Make the gravel wet at any time.



A schematic diagram of high rate trickling filter

Disadvantages:

1- Cost of pumps & equipment.
2- Decrease the overall efficiency of the plant.
3- Continuity of toxic components if it exists.

Advantage of distribution chamber :

1- Distribution of sewage on the total numbers of filters equally.
2- Continuity of flow with constant rate.
3- Changing from channels to pipe before filters.
4- Collection of recirculation with original sewage.

Typical design of trickling filters

Item	**Standard rate trickling filter**	**High rate trickling filter**
Operation	Intermittent	Continuous
Recirculation (R)	Zero	1 - 4.5
Depth	1.5 - 3 m	1 - 2 m
Allowable organic load (L)	80 - 320 KgB.O.D/1000 m^3/d	500 - 1000 KgB.O.D/1000 m^3 /d
Volume	T.O,L / L	T.O.L / L

Hydraulic load	1 - 4 $m^3/m^2/day$	10 - 30 $m^3/m^2/day$
Sloughing	Intermittent	Continuous
Design Equation Combined efficiency	$E = \dfrac{100}{1+0.0085\sqrt{2.7L}}$	$E = \dfrac{100}{1+0.0085\sqrt{\dfrac{2.7L}{F}}}$ $F = \dfrac{1+R}{(1+0.1R)^2}$
B.O.D. removal efficiency	80 - 90 %	65 - 85 %

Where:

F = recirculation factor = $(1+R)/(1+0.1R)^2$

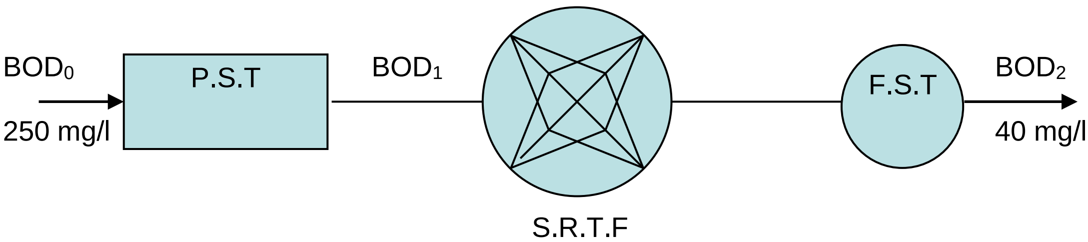
R= recirculation rate = Q_R/Q_d

Example:

A sewage treatment plant of daily discharge 18000 m^3. Find the numbers and dimensions of standard rate and high rate trickling filters if:

- Row sewage BOD5 =250 mg/l
- Effluent BOD5 = 40 mg/l
- BOD5 removal efficiency of primary sedimentation= 30%
- Recirculation ratio (R) is 1.5 the design flow.

Solution:



$BOD_1 = BOD_0\ (1 - 30/100)$

$= 250\ (1 - 30/100) = 175$ mg/l

$$Combined\ efficiency = \frac{BOD_1 - BOD_2}{BOD_1} \times 100$$

$$= \frac{175-40}{175} \times 100 = 77.1\,\%$$

$$Combined\ efficiency = \frac{100}{1+0.0085\sqrt{2.7L}}$$

$$77.1 = \frac{100}{1+0.0085\sqrt{2.7L}}$$

$$L = 452.71 \quad gm\ BOD / m^3 / d$$

$$Volume=\frac{Total\ organic load}{L}$$

$$=\frac{Q_d\times BOD_1}{L}=\frac{18000\times175}{452.71}=6958.1\quad m^3$$

$$Assume\ d=2\ m\qquad d=1.5-3m$$

$$Surface\ area=\frac{V}{d}=\frac{6958.1}{2}=3479.05\quad m^2$$

$$Assume\ \phi=40m$$

$$Surface\ area\ of\ one\ filter=\frac{\pi\phi^2}{4}=\frac{\pi\times(40)^2}{4}=1256.6\quad m^2$$

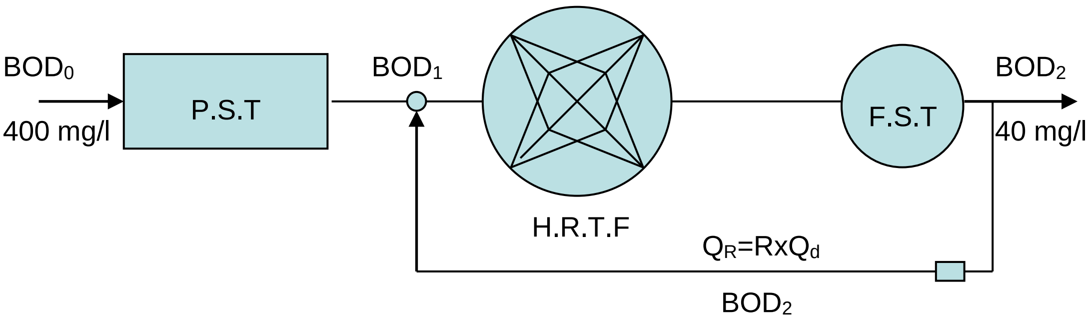
$$No.\ of\ filters=\frac{area\ of\ filters}{area\ of\ one\ filter}=\frac{3479.05}{1256.6}=2.77\approx3\ filters$$

$$\frac{\pi\phi^2{}_{act}}{4}=\frac{3479.05}{3}\qquad\therefore\phi_{act}=38.43m$$

$$Check:$$

$$Hydrolic load=\frac{Q_d}{S.A}=\frac{18000}{3\times\frac{\pi}{4}\times(38.43)^2}=1.29\quad m^3/m^2/d$$

$$Hydrolic load=1-4\quad m^3/m^2/d$$



$$Combined\ efficiency=\frac{BOD_1-BOD_2}{BOD_1}\times100$$

$$=\frac{175-40}{175}\times100=77.1\,\%$$

$$Combined\ efficiency=\frac{100}{1+0.0085\sqrt{\frac{2.7L}{F}}}$$

$$F=\frac{1+R}{(1+0.1R)^2}=\frac{1+1.5}{(1+0.1\times1.5)^2}=1.89$$

$$77.1=\frac{100}{1+0.0085\sqrt{\frac{2.7L}{1.89}}}$$

$$L=854.7 \quad gm\ BOD/m^3/d$$

$$Volume=\frac{Total\ organic load}{L}$$

$$=\frac{Q_d\times BOD_1+Q_R\times BOD_2}{L}=\frac{18000\times175+1.5\times18000\times40}{854.7}=4949.1 \quad m^3$$

$$Assume\ d=1.5\ m \qquad d=1-2m$$

$$Surface\ area=\frac{V}{d}=\frac{4949.1}{1.5}=3299.4 \quad m^2$$

$$Assume\ \phi=40m$$

$$Surface\ area\ of\ one\ filter=\frac{\pi\phi^2}{4}=\frac{\pi\times(40)^2}{4}=1256.6 \quad m^2$$

$$No.of\ \ filters=\frac{area\ of\ \ filters}{area\ of\ one\ filter}=\frac{3299.4}{1256.6}=2.63\approx3\ filters$$

$$\frac{\pi\phi^2{}_{act}}{4}=\frac{3299.4}{3} \qquad \therefore\phi_{act}=37.42m$$

$$Check:$$

$$Hydrolic load=\frac{Q_d+Q_R}{S.A}=\frac{18000+(1.5\times18000)}{3\times\frac{\pi}{4}\times(37.42)^2}=13.64 \quad m^3/m^2/d$$

$$Hydrolic load=10-30 \quad m^3/m^2/d$$