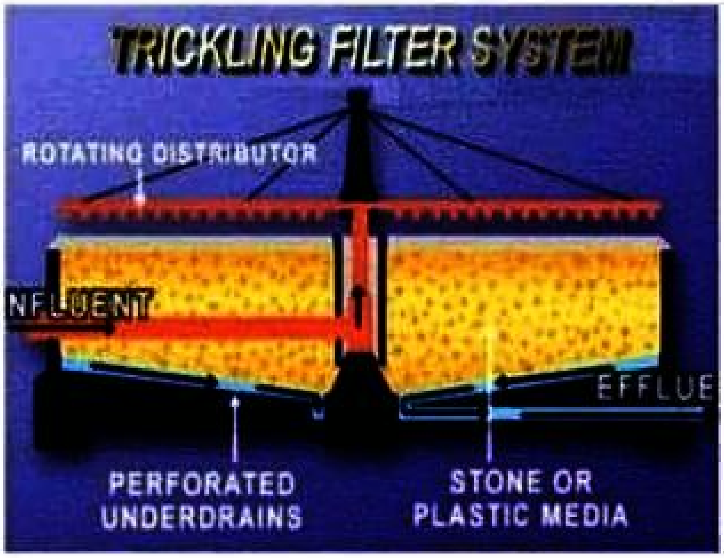
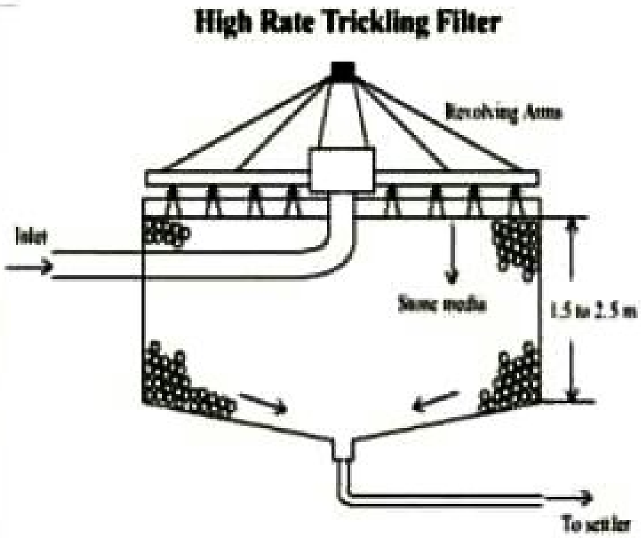
Trickling Filters

Trickling filter is an *attached growth process,* i.e. process in which microorganisms responsible for treatment are attached to an inert packing material in the presence of oxygen. Packing materials used in attached growth processes include rock, gravel, slag, sand, redwood, and a wide range of plastic and other synthetic materials.

Purpose:

Stabilize organic matter and make it satiable.





A schematic diagram of standard rate trickling filter

Filter media used:

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

Under drainage system:

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.

Advantage of distribution chamber:

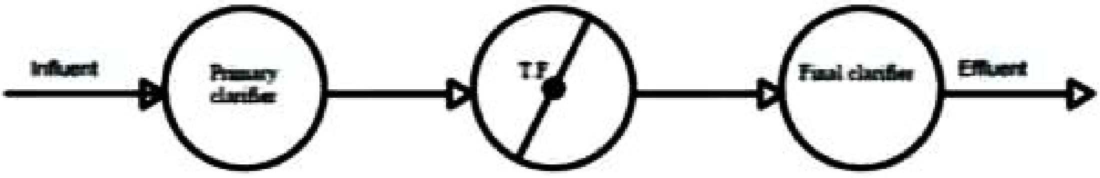
1) Continuity of flow with constant rate.
2) Changing from channels to pipe before filters.
3) Collection of recirculation with original sewage.
4) Distribution of sewage on the total numbers of filters equally.

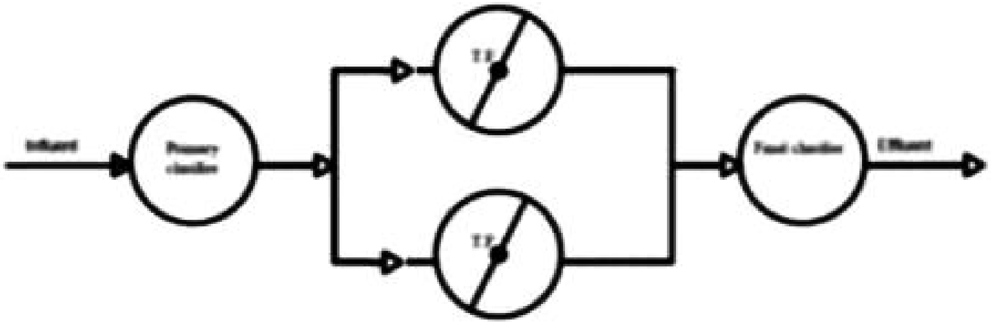
Dosing chamber:

1) Control the quantity of sewage required to make complete rotation by the arms.
2) Make the flow discontinuous to give the chance for the reaction between aerobic bacteria and organic matter to take place.
3) Assure the continuity of arms rotation

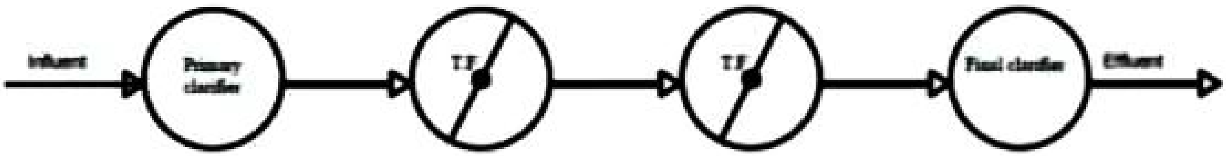
Flow scheme

1. **Single stage**



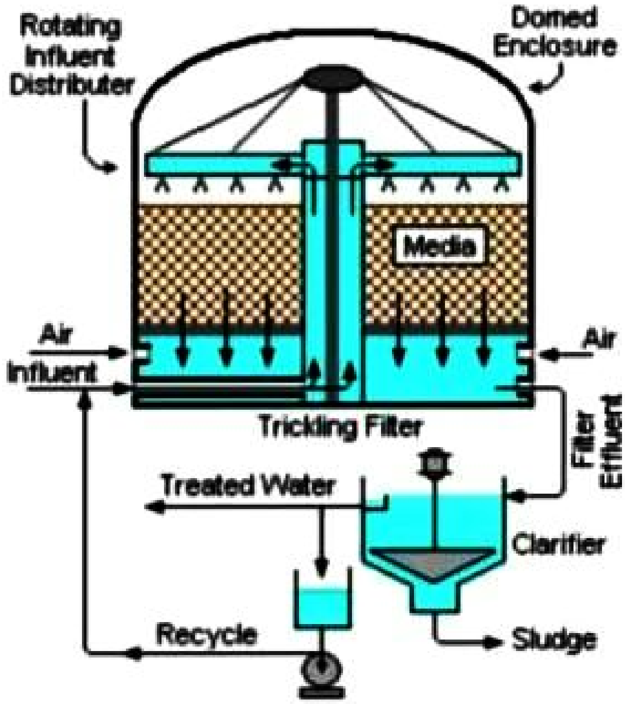


i) **Double or two stages in Series**



Recirculation process in trickling filter

Recirculation of wastewater is generally practiced in modern trickling filter plants. Techniques of recirculation vary widely, with at least fourteen different configuration being use (see text book fig. 24-6 page 483).



Advantages of recirculation:

1) Return 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.

Efficiency of Trickling filter

Efficiency = f (Recirculation ratio, organic, Loading rate)

National Research Centre (NRC) formula for single stage T.F

- For single stage T.F

$$E_1 = \frac{C_i - C_e}{C_i} = \frac{1}{1+0.532\sqrt{\frac{Q \cdot C_i}{V \cdot F}}}$$

Where:

E_1: Efficiency for single stage;

C_i: influent BOD concentration mg/L

C_e: effluent BOD concentration mg/L;

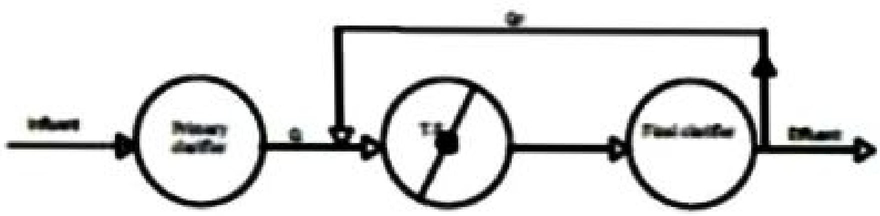
Q: influent discharge m^3/min

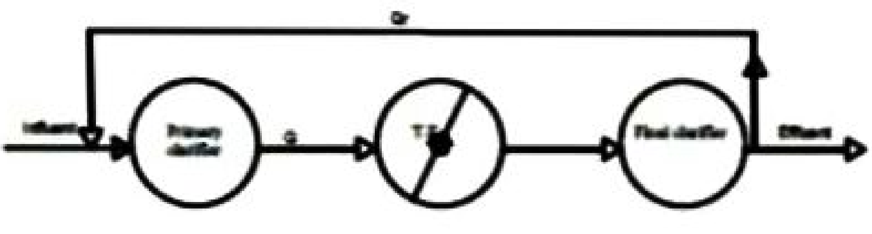
V: volume of filter (media) m^3;

F: Recirculation factor

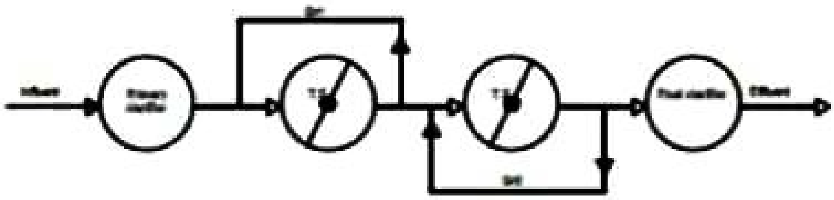
$$F = \frac{1+r}{(1+0.1\,r)^2}\,;\, r = \frac{Q_r}{Q}$$

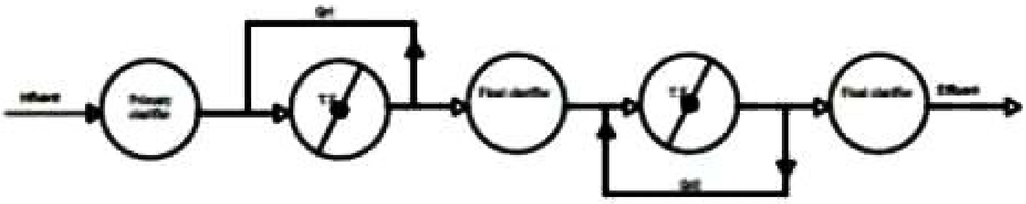
In which r is the ratio of the recirculated flow to the raw waste flow.





For the second stage the formula becomes:





$$E_2 = \frac{C_i - C_e^-}{C_i} = \frac{1}{1 + \frac{0.532}{1 - [(C_i - C_e)/C_i]} \sqrt{\frac{Q \cdot C_e}{V^- \cdot F^-}}}$$

In which:

E_2: Efficiency for double stage.

Ce: effluent BOD concentration from first stage

C_e^- is the effluent BOD of the second stage,

V^- and F^- are the volume and recirculation factor for the second stage,

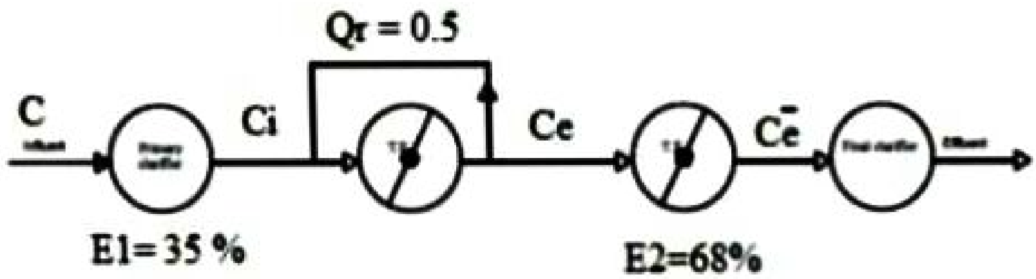
$$F^- = \frac{1+r^-}{(1+0.1\,r^-)^2}\;;\; r^- = \frac{Q_r^-}{Q}$$

Example:

Find BOD concentration in the plant effluent and overall percent reduction in BOD for the following data:

- Flow 2.63 m^3/min; - BOD concentration in raw ewage=308 ppm
- 35% BOD removal in primary settling; -volume of filter (first stage) = 826 m^3
- volume of filter (second stage) = 2563 m^3
- recirculation rate= 0.5 in first tank while no recirculation in second stage

Solution:



$$E_1 = \frac{1}{1+0.532\sqrt{\frac{Q \cdot C_e}{V \cdot F}}}$$

$$E_1 = \frac{C - C_e}{C}$$

$$0.35 = \frac{308 - C_e}{308};\ C_e = 200 \text{ ppm}$$

$$F = \frac{1+r}{(1+0.1\,r)^2} = \frac{1+0.5}{(1+0.1 \cdot 0.5)^2} = 1.36$$

$$E_1 = \frac{1}{1+0.532\sqrt{\frac{2.63 \cdot 200}{826 \cdot 1.36}}} = 0.74 = 74\%$$

$$0.74 = \frac{200 - Ce}{200};\ Ce = 52 \text{ ppm}$$ (influent BOD concentration for 2nd stage)

$$E_2 = \frac{1}{1+\frac{0.532}{1-E_1}\sqrt{\frac{Q \cdot C_e}{V^- \cdot F^-}}}$$

$$F^- = \frac{1+r^-}{(1+0.1\,r^-)^2} = 1\ (no\ recirculation)$$

$$E_2 = \frac{1}{1+\frac{0.532}{1-0.74}\sqrt{\frac{2.63 \cdot 52}{2563 \cdot 1}}} = 0.68 = 68\%$$

$$0.6 = \frac{52 - Ce}{52};\ Ce = 16.6 \text{ ppm}$$

$$\text{Overall removal efficiency} = \frac{308 - 16.6}{308} \cdot 100 = 95\%$$