FAQs

1. **Question: Explain** National Research Council of USA **equation**

Answer: These equations are applicable to both low rate and high rate filters. The efficiency of single stage or first stage of two stage filters, E_2 is given by

$$\mathbf{E_2}= \frac{100}{1+0.44\,(F_{1.BOD}/V_1.Rf_1)^{1/2}}$$

For the second stage filter, the efficiency E_3 is given by

$$\mathbf{E_3}= \frac{100}{[(1+0.44)/(1- E_2)](F_{2.BOD}/V_2.Rf_2)^{1/2}}$$

Where,

$\mathbf{E_2}$= % efficiency in BOD removal of single stage or first stage of two-stage filter

$\mathbf{E_3}$=% efficiency of second stage filter

$\boldsymbol{F_{1.BOD}}$= BOD loading of settled raw sewage in single stage of the two-stage filter in kg/d

$\boldsymbol{F_{2.BOD}}= F_{1.BOD}(1- E_2)$= BOD loading on second-stage filter in kg/d,

$\mathbf{V_1}$= volume of first stage filter, m^3

$\mathbf{V_2}$= volume of second stage filter, m^3

$\mathbf{Rf_1}$= Recirculation factor for first stage

$\mathbf{R_1}$= Recirculation ratio for first stage filter

$\mathbf{Rf_2}$= Recirculation factor for second stage

$\mathbf{R_2}$= Recirculation ratio for second stage filter

2. **Discuss Rankins equation**

This equation also known as tentative method of ten states. USA has been successfully used this equation over wide range of temperature. It requires following conditions to be observed for single stage filters:

1. Raw settled domestic sewage BOD applied to filters should not exceed 1.2 kg BOD_5/day/ m^3 filter volume.
2. Hydraulic load (including recirculation) should not exceed 30 m^3/m^2 filter surface-day.
3. Recirculation ratio (R/Q) should be such that BOD entering filter (including recirculation) is not more than three times the BOD expected in effluent. This implies that as long as the above conditions are satisfied efficiency is only a function of recirculation and is given by:

$$E = \frac{(R/Q) + 1}{(R/Q) + 1.5}$$

In order to achieve optimum operation, several design criteria for trickling filters must be followed:

- Roughing filters may be loaded at a rate of 4.8 kg BOD_5/day/m^3 filter media and achieve BOD_5 reductions of 40–50%;
- High-rate filters achieve BOD_5 reductions of 40–70% at organic loadings of 0.4–4.8 kg/BOD_5/day/m^3; and
- Standard rate filters are loaded at 0.08–0.4 kg/BOD_5/day/m^3 and achieve BOD_5 removals greater than 70%.

3. Explain the different steps involved in trickling filter

The following steps were observed in trickling filter process

- ❖ The wastewater in trickling filter is distributed over the top area of a vessel containing non-submerged packing material.
- ❖ Air circulation in the void space, by either natural draft or blowers, provides oxygen for the microorganisms growing as an attached biofilm.
- ❖ During operation, the organic material present in the wastewater is metabolised by the biomass attached to the medium. The biological slime grows in thickness as the organic matter abstracted from the flowing wastewater is synthesized into new cellular material.
- ❖ The thickness of the aerobic layer is limited by the depth of penetration of oxygen into the microbial layer.
- ❖ The microorganisms near the medium face enter the endogenous phase as the substrate is metabolized as a result of increased thickness of the slime layer and lose their ability to cling to the media surface. The liquid then washes the slime off the medium and a new slime layer starts to grow. This phenomenon of losing the slime layer is called ***sloughing***.
- ❖ The sloughed off film and treated wastewater are collected by an under drainage which also allows circulation of air through filter. The collected liquid is passed to a settling tank used for solid- liquid separation.

4. Write a note on microbiology of trickling filter

Two types of microorganisms live in waters: suspended organisms, floating in the water, and sessile organisms, which often settle on the surface of stones and form

biofilms. Biofilm processes such as fixed-bed or trickling filter processes are examples of the technical application of these natural processes.

Typical microorganisms present in trickling filters are *Zoogloea*, *Pseudomonas*, *Alcaligenes*, *Flavobacterium*, *Streptomyces*, *Nocardia*, fungi, and protozoa. The crux of the process is that the organic contents of the effluents are degraded by these attached growth populations, which absorb the organic contents from the surrounding water film. Oxygen from the air diffuses through this liquid film and enters the biomass. As the organic matter grows, the biomass layer thickens and some of its inner portions become deprived of oxygen or nutrients and separate from the support media, over which a new layer will start to grow. The separation of biomass occurs in relatively large flocs that settle relatively quickly in the supporting material. Media that can be used are rocks (low-rate filter) or plastic structures (high-rate filter). Denitrification can occur in low-rate filters, while nitrification occurs under high-rate filtration conditions; therefore, effluent recycle may be necessary in high-rate filters.

5. Discuss different types filters used in trickling filter.

Trickling filters are classified as high rate or low rate, based on the organic and hydraulic loading applied to the unit.

Sl.No.	Design Feature	Low Rate Filter	High Rate Filter
1.	Hydraulic loading, $m^3/m^2.d$	1 - 4	10 - 40
2.	Organic loading,kg BOD / $m^3.d$	0.08 - 0.32	0.32 - 1.0
3.	Depth, m.	1.8 - 3.0	0.9 - 2.5
4.	Recirculation ratio	0	0.5 - 3.0 (domestic wastewater) upto 8 for strong industrial wastewater.

- The hydraulic loading rate is the total flow including recirculation appied on unit area of the filter in a day, while the organic loading rate is the 5 day 20°C BOD, excluding the BOD of the recirculant, applied per unit volume in a day.
- Recirculation is generally not adopted in low rate filters.

- A well operated low rate trickling filter in combination with secondary settling tank may remove 75 to 90% BOD and produce highly nitrified effluent. It is suitable for treatment of low to medium strength domestic wastewaters.
- The high rate trickling filter, single stage or two stage are recommended for medium to relatively high strength domestic and industrial wastewater. The BOD removal efficiency is around 75 to 90% but the effluent is only partially nitrified.
- Single stage unit consists of a primary settling tank, filter, secondary settling tank and facilities for recirculation of the effluent. Two stage filters consist of two filters in series with a primary settling tank, an intermediate settling tank which may be omitted in certain cases and a final settling tank.

6. List out potential causes and remedy for trickling filter?

Potential Cause: Excessive organic load causing anaerobic decomposition in filter.

Remedy: Reduce loading; increase BOD removal in primary settling tanks; enhance aerobic conditions in treatment units by adding chemical oxidants, preaerating, recycling plant effluent, or increasing air to aerated grit chambers; scrub off gases; use plastic media instead of rock.

Potential Cause: Inadequate ventilation.

Remedy: Increase hydraulic loading to wash out excess biological growth; remove debris from filter effluent channels, underdrains, and the top of filter media; unclog vent pipes; reduce hydraulic loading if underdrains are flooded; install fans to induce draft through filter; check for filter plugging resulting from breakdown of the medium.

Along with this several other factors such as ponding on filter media, icing, rotating distributor slows down or stops need to be considered while operating the TF.