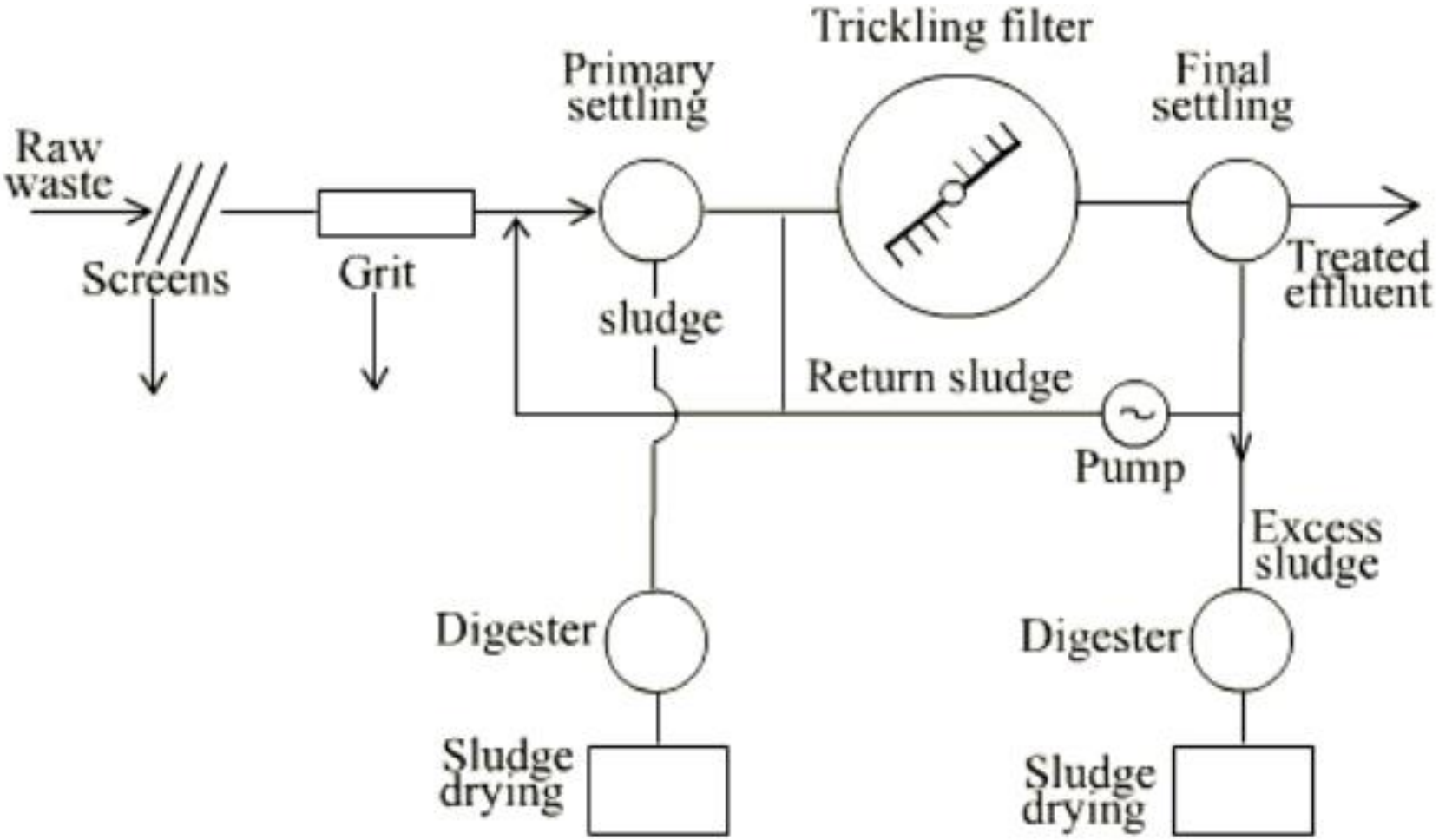
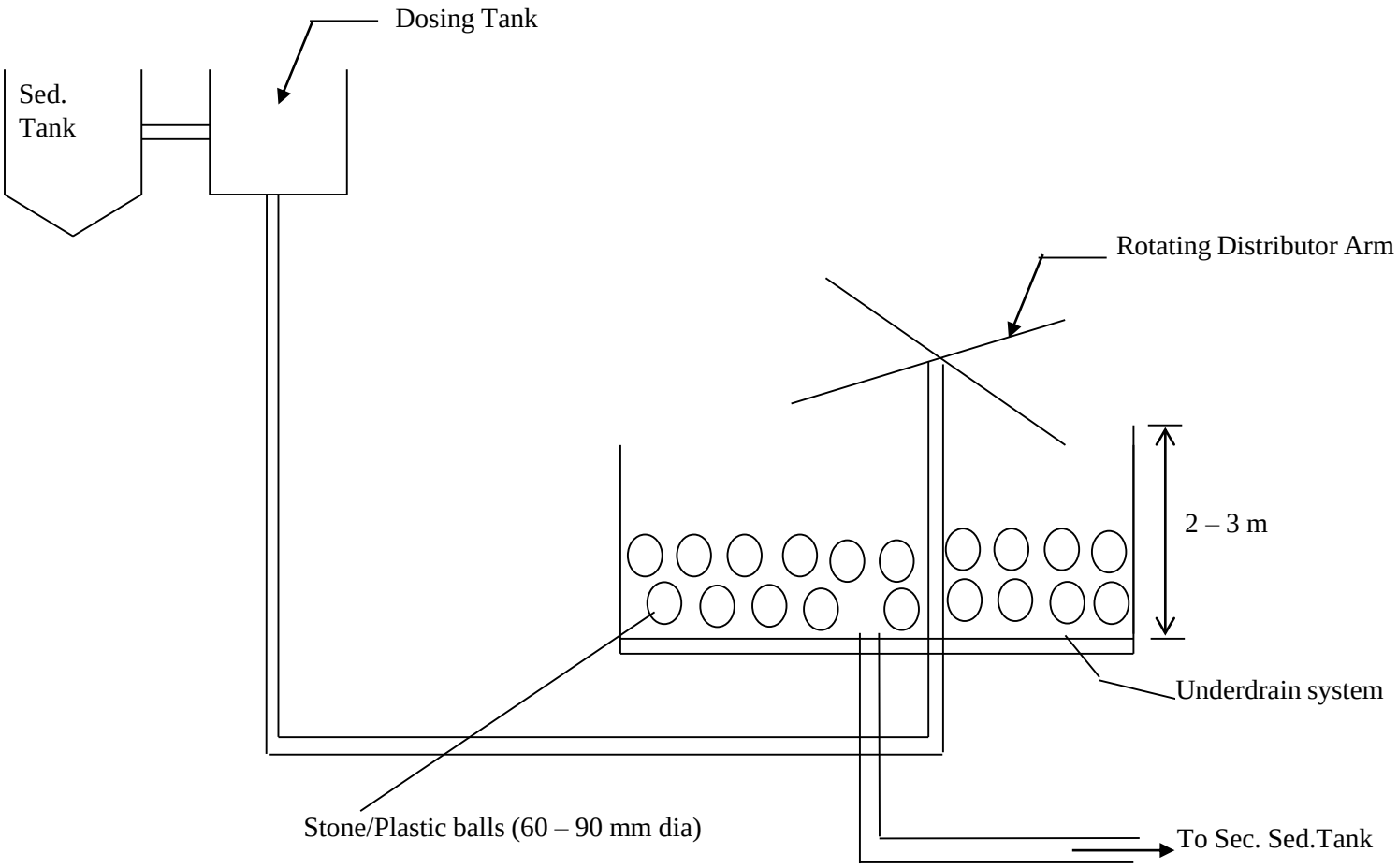
# Secondary Treatment (Trickling Filters)

# Tricking filter(TF)

Suspended growth




Dosing Tank
Sed.
Tank
Rotating Distributor Arm
2 – 3 m
Underdrain system
Stone/Plastic balls (60 – 90 mm dia)
To Sec. Sed.Tank

# Tricking filter(TF)

- A trickling filter consists of a bed of highly permeable media on which microorganisms grow and through which wastewater is percolated or trickled.
- As the wastewater flows through the media the organisms, attached on the surfaces, remove the organic matter from the flow.
- The process is an attached-growth aerobic biological treatment method designed to remove BOD and suspended solids.

# Tricking filter(TF)

Theory of Trickling Filter

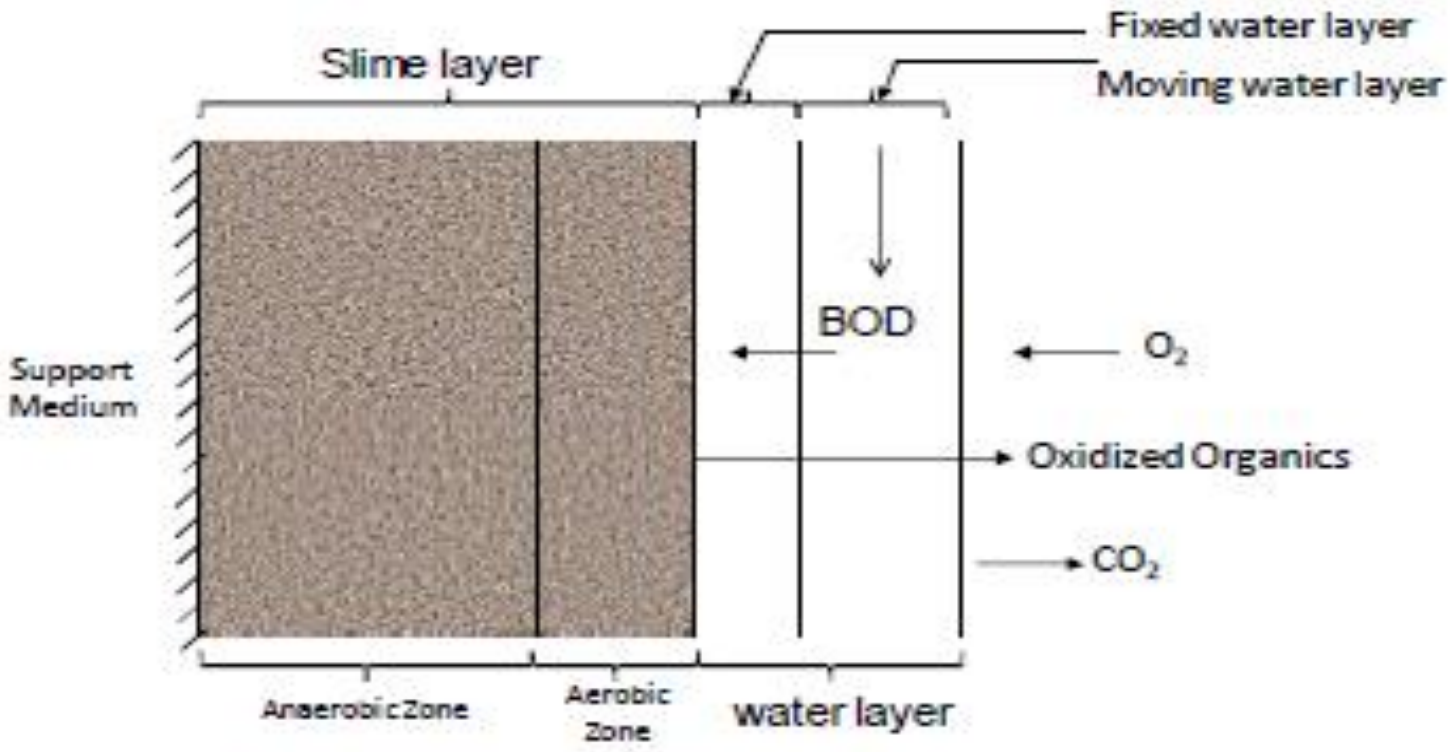



Fig: Schematic diagram of attached growth process

# Tricking filter(TF)

Theory of Trickling Filter

- Wastewater is applied to the surface and percolates through the filter, flowing over the biological growth in a thin film.
- Nutrients, oxygen and organic matter are transferred to the fixed water layer (and from there to bacteria) and waste products are transferred to the moving water layer, primarily by diffusion.
- As the bacteria on filter medium metabolize the waste and reproduce, they will gradually cause an increase in the thickness of Slime Layer.

# Tricking filter(TF)

Theory of Trickling Filter

- With thickening of biological layer, the bacteria in the interior layers find themselves in a food limited & anaerobic situation, since the organic matter and oxygen are utilized near the surface before they can reach the microorganisms near the media surface.
- Eventually these interior cells near the media surface die breaking the contact between slime layer and support medium.
- When sufficient cells have died, the slime layer will slough off and be carried from the filter by the waste flow and a new layer starts to grow.
- These solids in the filter effluent are removed from the flow in a secondary clarifier.

# Tricking filter(TF)

MajorComponents:

**Distribution system:**

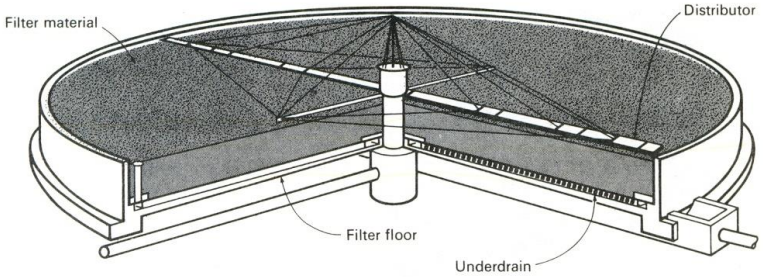
- Rotary distributors having 2 to 4 arms,
- The arms are hollow and contains nozzles through which wastewater is discharged over the filter bed.
- Driven either by motor or by dynamic reaction of wastewater discharging from the nozzles.

**Filter Media:**

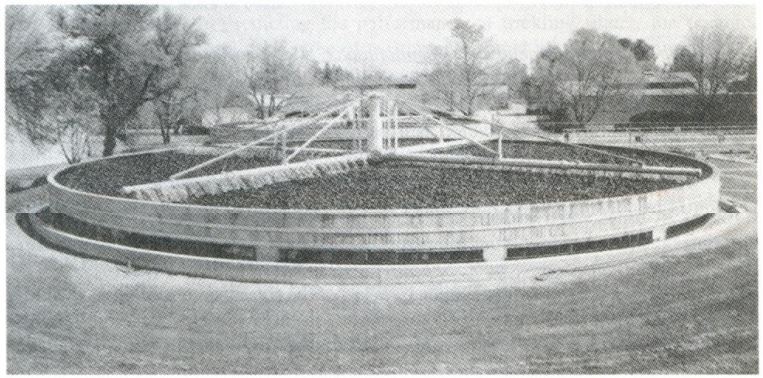
- Rock (crushed stone, gravel etc) varying in size from 60 to 90 mm
- Plastic (interlocking sheets, or molded shapes)

**Collection system:** (for collection of treated effluent and sloughed solids and for supply of oxygen through the filter)

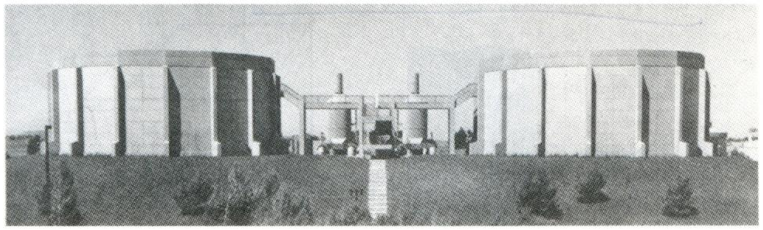
**Recirculation pumps and piping**




(a)



(b)



(c)

**FIGURE 8-22**
Typical trickling filters: (*a*) cutaway view of a trickling filter (from Dorr-Oliver), (*b*) conventional rock-filled type filter, and (*c*) tower trickling filters.

# Tricking filter(TF)

RECIRCULATION:

- In practice, a portion of the wastewater collected in the under-drainage system or settled effluent is recycled through the bed.

Recirculation has the following advantages;

- Dilution of the influent wastewater.
- Maintenance of more uniform hydraulic and organic loading.
- Reduce odor and fly problem.

# Tricking filter(TF)

Pretreatment Required:

- Primary Sedimentation.

Classification of Trickling Filters:

- Trickling filters are classified as ***standard or low rate***, ***and high-rate*** filters according to hydraulic and organic loading rates.
- Two-stage operation, the placing of two filters in series, is used for high organic loads.

# Design Criteria for Trickling Filter

| | Factor | Low Rate | High Rate |
|---|---|---|---|
| 1. | Medium | Stone | Plastic balls |
| 2. | Hydraulic Loading | 1.9-3.8 $m^3/m^2.d$ | 9-27 $m^3/m^2.d$ |
| 3. | Depth | 2-3 m | 1-2.5 m |
| 4. | Recirculation | NIL | 1:1 to 4:1 to 7:1 |
| 5. | Operation | Simple | Skilled |
| 6. | Odor/Fly | Comparatively more | Less |
| 7. | Organic loading | 0.3-1.5 kg $BOD/m^3$ filter vol-day | 1.5-18.5 kg $BOD/m^3$ filter vol-day |
| 8. | Configuration | Single stage | Single or double stage |

# Tricking filter(TF)

ADVANTAGES OF T.F :

- Satisfactory BOD reduction
- Effective in handling shock loads
- Low operating cost

DISADVANTAGES OF T.F :

- Significant head loss (3-5 m)
- Experts required for design, construction and maintenance
- Not all parts and materials may be available locally
- High construction cost
- Odor and fly problem

# Tricking filter(TF)

Performance efficiency :

National research council empirical formula is used for calculating efficiency of TF:

$$E = \frac{C_i - C_e}{C_i} = \frac{1}{1 + 0.532\sqrt{\frac{QC_i}{VF}}}$$

Where;

Ci = Influent BOD, mg/L

Ce = Effluent BOD, mg/L

V = Filter Volume, m3

Q = Flow, m3/min

F = Recirculation Factor $= \frac{1+r}{(1+0.1r)^2}$

Where, r = Qr/Q= Recirculation ratio

# Tricking filter(TF)

Performance efficiency :

The efficiency of the second stage of two stage filters is given by;

$$E = \frac{C_i - C_e}{C_i} = \frac{1}{1 + \frac{0.532}{1 - E}\sqrt{\frac{QC_i}{VF}}}$$

Where V' and F' are the volume and recirculation factor for the second stage and other terms are as defined earlier.

Hydraulic Loading

$$\text{H.L} = \frac{Q + Qr}{Area}$$

## Problem 1

Calculate the volume and depth of low rate trickling filter to treat a flow of 7560 $m^3$/day. The BOD of settled sewage is 200 mg/L. Assume organic loading rate of 0.3 kg of BOD per $m^3$ of filter volume per day and hydraulic loading rate of 3 $m^3$ /$m^2$.day.

## Problem 2

Calculate the volume and depth of a high rate trickling filter to treat a flow of 10,000$m^3$/day. The BOD of the settled sewage is 400 mg/L. Assume organic loading rate of 2.5 kg of BOD /$m^3$.day and hydraulic loading rate of 25 $m^3$/$m^2$.day.It is intended to employ a recirculation ratio of 1:1.

# Problem 3

Calculate the effluent BOD of a trickling filter with following data:

- Q=3.15 $m^{3/}$min
- Influent BOD= 290 mg/L
- Volume of filter=830 $m^3$
- Filter depth= 2 m
- r= 1.25

# Problem 4

A settled sewage flow of 11355 $m^3$/day containing 150 mg/L of BOD is to be treated by TF with a depth of 2m. It is desired that effluent BOD should be 20 mg/L. Calculate the required diameter of the filter and the hydraulic loading of the filter , $Q_r/Q$=1.

# Problem 5

Calculate the effluent BOD of a two stage TF . Each stage has an area of 430 $m^2$, a depth of 2 m, and a recirculation rate of 125% of the flow. The flow is 3.15 m3/min and the influent BOD is 170 mg/l following primary treatment. Also find the effluent BOD if there were only one filter of twice the area.