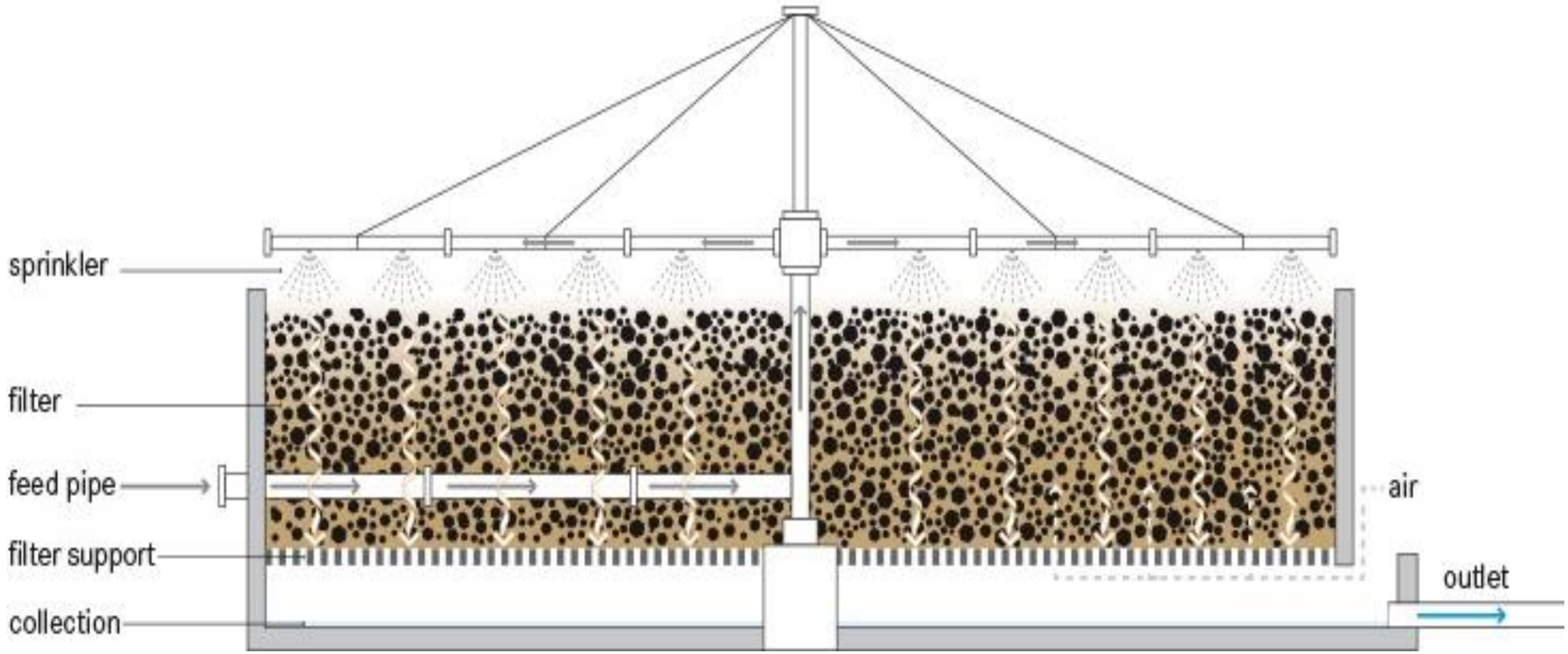
CHAPTER 8

TRICKLING FILTERS

TRICKLING FILTERS

- A reactor in which randomly packed solid forms provide surface area for biofilm growth



Trickling Filter

Three major components :

1. Filter medium

- Provide a surface for biological growth and voids for passage of liquid and air
- Medium commonly used : crushed stone ,slag, plastic packing
- The ideal filter material is low-cost and durable, has a high surface to volume ratio, is light, and allows air to circulate

Crushed-rock

Plastic random pack

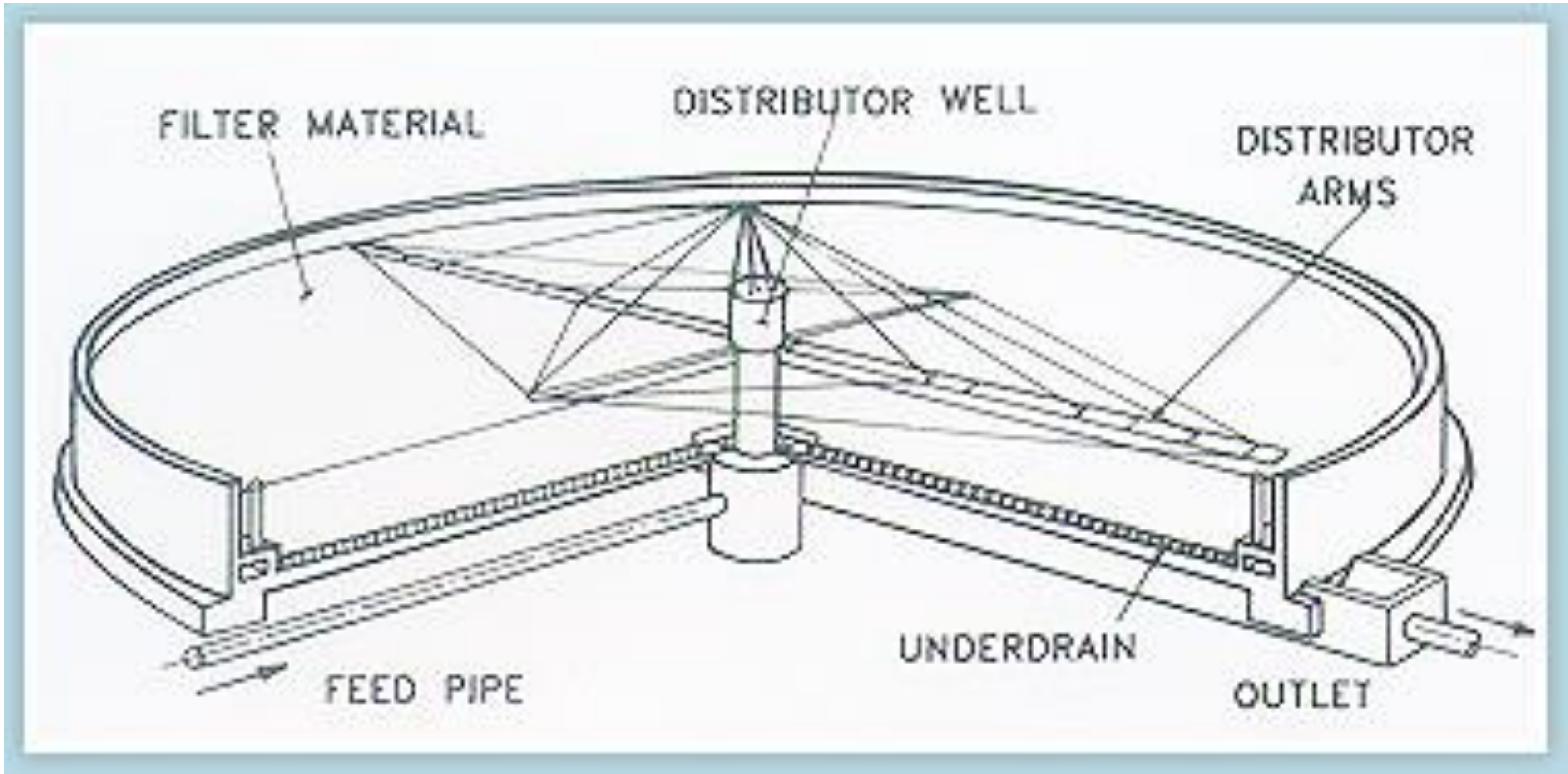
Plastic-cross flow

2. Rotary distributor

- Provides uniform hydraulic load on the filter surface

3. Underdrain system

- carry away the treated wastewater and the sloughed biomass



- Often operated in series to increase the effective contact time with the biofilm.
- Generally followed by a secondary clarifier to remove sloughed solids.
- *Factors affecting the operation:*
  - Organic loading.
  - Hydraulic flow rates.
  - Temperature of water and ambient air.

Disadvantages

- Not as efficient as newer treatment methods - limited future
- Large land requirement
- Variations in effluent quality
- Odor problems, filter flies

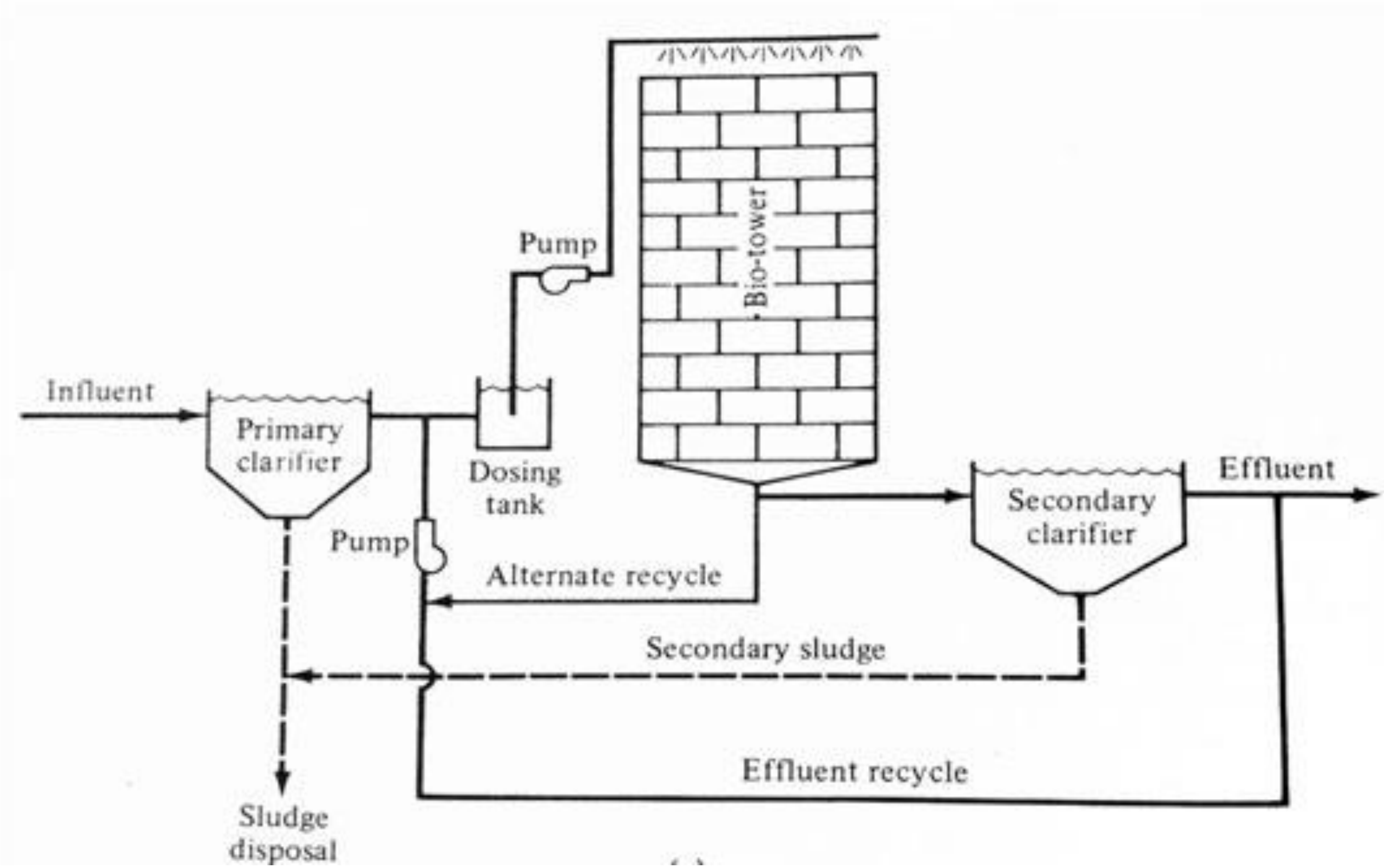
Disadvantages .. Cont.:

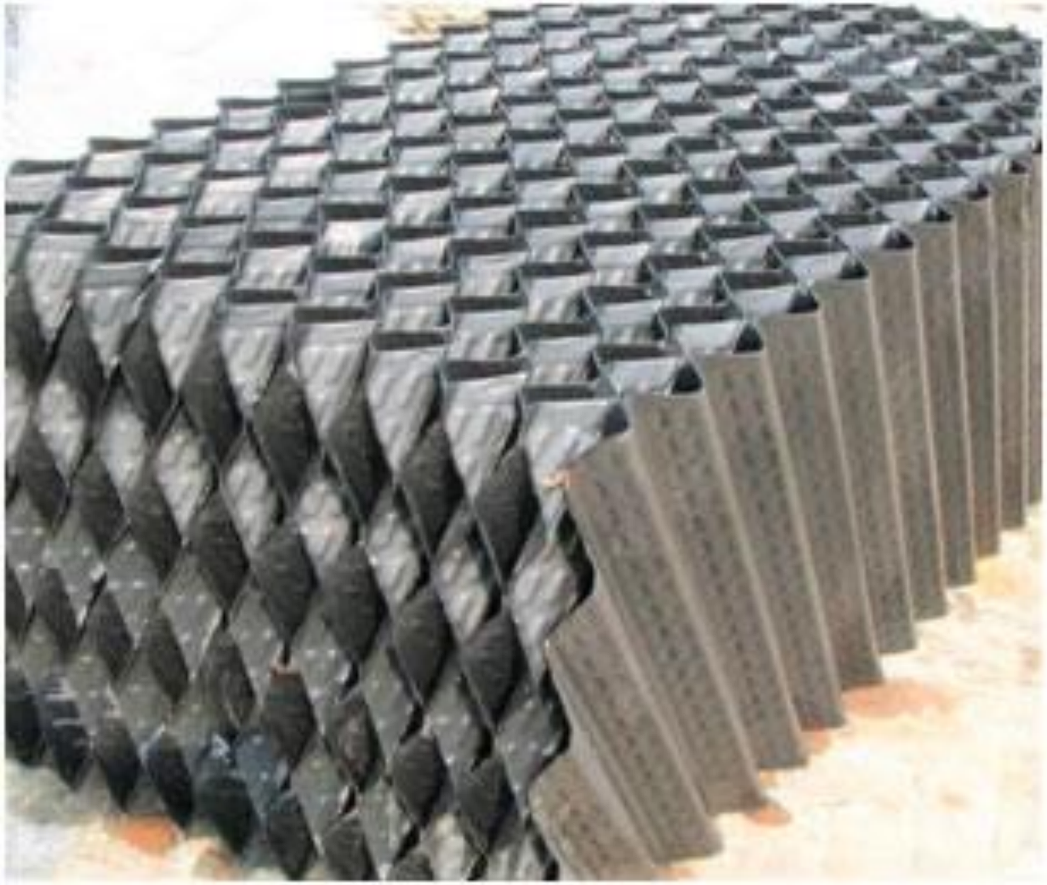
High organic loading rate → Excessive biomass growth → Plugging of pores

Sensitive to temperature variations → Unstable effluent quality

BIO-TOWERS

- Innovation from trickling filters (essentially deep trickling filters)
- Plastic medium
  - effectively prevents blockage
  - ensures an adequate flow of air
  - small area


Pump
Bio-tower
Influent
Primary clarifier
Dosing tank
Pump
Alternate recycle
Secondary clarifier
Effluent
Secondary sludge
Effluent recycle
Sludge disposal



Bio-tower media

Advantages over trickling filters

- The porosity and nature of the packing allow greater loading rates and virtually eliminate plugging problems.
- Increase ventilation minimizes odour problem under most operating conditions
- The compact nature of the reactor allows economical operations.

Design

Hydraulic loading, Q_v

$$Q_v = \frac{Q}{A} m^3 / m^2 . \min \qquad (8.1)$$

where

Q = flow rate without recirculation, m^3/min

A = area

BOD loading

$$W = I_i Q \quad (8.2)$$

where

I_i = influent substrate concentration, BOD_5 mg/L

Q = wastewater flowrate

Eckenfelder formula (with recirculation)

$$\frac{l_e}{l_a} = \frac{e^{-kD/Q_v^n}}{(1+R) - \mathrm{R}e^{-kD/Q_v^n}} \qquad (8.3)$$

Where

l_e = effluent substrate concentration, BOD_5 mg/L

D = depth of the medium, m

k = treatability constant relating to the wastewater and the medium characteristics, min^{-1} = 0.06 min^{-1}

n = coefficient relating to the medium characteristics = 0.5

R = ratio of the recycled flow to the influent flow = Q_r/Q

Q_r = recirculation flow rate

l_a = BOD_5 of the mixture of raw and recycled mixture

$$= \frac{l_i + R l_e}{1 + R}$$

Correction for other temperature can be made by adjusting the treatability factor:

$$K_T = K_{20^o C}(1.035)^{T-20} \qquad (8.4)$$

Example

An existing 6 m deep tower trickling filter plant cannot meet the effluent standard of less than 10 mg/L. The plant influent BOD is 220 mg/L, the primary effluent BOD is 150 mg/L, the plant final effluent is 30 mg/L and the recirculation flow is 1.5 of the wastewater flow entering the plant. One proposal is to change the recirculation ratio, to reduce the effluent BOD from 30 to 10 mg/L. The constants for the random plastic media, n of 0.44 and K_{20} of 0.055 min^{-1}. Design temperature is 25^{o}C.

i. Calculate the hydraulic loading

ii. By using the recirculation ratio = 2.0, check whether the plant effluent meet the standard

Solution

i. The treatability constant must be adjusted for temperature

$$K_{25} = K_{20}(1.035)^{25-20}$$

$$= 0.055\,(1.035)^{5} = 0.065\ \text{min}^{-1}$$

ii. The hydraulic loading, Q_v

$$l_a = \frac{l_i + Rl_e}{1+R}$$

$$l_a = \frac{150+1.5(30)}{1+1.5} = 78mg/L$$

$$\frac{l_e}{l_a} = \frac{e^{-kD/Q_v^n}}{(1+R) - \mathrm{Re}^{-kD/Q_v^n}}$$

$$\frac{30}{78} = \frac{e^{-0.065(6) / Q_v^{0.44}}}{(1+R) - \mathrm{R}e^{-0.065(6) / Q_v^{0.44}}}$$

If $m = 0.065(6) / Q_v^{0.44}$

$$\frac{30}{78} = \frac{e^{-m}}{(1 + 1.5) - 1.5e^{-m}}$$

$$0.39 = \frac{e^{-m}}{2.5 - 1.5e^{-m}}$$

$$1.585e^{-m} = 0.975$$

$$e^{-m} = 0.61$$

$$m = 0.494 = 0.065(6) \Big/ Q_v^{0.44}$$

$$Q_v^{0.44} = 0.789$$

$$Q_v = 0.584 \text{ m}^3/\text{m}^2.\text{min}$$

iii. R = 2

$$\frac{l_e}{l_a} = \frac{e^{-0.065(6)/0.584^{0.44}}}{(1+2) - 2e^{-0.065(6)/0.584^{0.44}}}$$

$$= \frac{0.610}{3 - (2x0.610)} = 0.343$$

$$\frac{l_e}{l_a} = \frac{l_e}{\left(\frac{150 + 2l_e}{3}\right)} = 0.343$$

$$l_e = 17.13 + 0.228 l_e$$

$$l_e = 22.19\ mg/L > 10 mg/L$$

Not Satisfying