Attached Growth Biological Systems

- Trickling Filters (misnomer)
- Biotowers
- Rotating Biological Contactors
- Wetlands, Leach Fields, Land-based systems

Aerobic Biological Systems

- Bacteria grow on fixed media (like rocks, plastic, teeth)
- Heterotrophic bacteria consume soluble BOD
- Nitrifiers consume NBOD if conditions right

Biofilm Schematic

- Outer portion of biofilm aerobic
- If film gets too thick then inner portion can go anaerobic
- When microorganisms near media surface die, lose ability to cling to surface and biofilm sloughed off
- New biofilm grows
Design Parameters

- **Organic Loading Rate (OLR)**
- **Mass Flux/volume (M/t·L³)**
- Empirically determined
- Low range determined by sufficient food for bacteria
- High range determined by oxygen limitations

- **Hydraulic Loading Rate (HLR)**
- Flow/area (L/t)
- Empirically derived
- Low range determined by adequately wetting biofilm
- High range determined by shearing of biofilm and ponding (low oxygen)

Trickling Filters

- Use tables of HLR and OLR to determine Volume and Area.
- Check both at both high and low values of range
- Use Eckenfelder or Velz equation to determine effluent concentration (Ce)
Trickling Filters

- A bed of highly permeable medium to which microorganisms attach
- Wastewater trickled through medium (rotating arm or sprinkler system) to maintain aerobic environment
- Underdrain collects treated wastewater and detached film (ventilation system if needed)
- Settling tank needed (often effluent (not sludge) recycled to trickling filter)
Low Rate Rock Example

T&S problem 14.11

- No recirculation
- Depth 1-3 m
- HLR=Q/A
- OLR=Q Cin/V
- From table (T&S pg 627):
  - HLR (m³/m²•d)=0.5-3.0
  - OLR (kg BOD₅/m²•d)=0.1-0.4
- For domestic wastewater a good rule of thumb:
  - BOD₅ = 0.68 BOD₅

Let’s use a mid range value for HLR (2 m³/m²•d). The necessary area would be:
  \[ A = \frac{Q}{HLR} = \frac{0.2 \text{ m}^3/\text{s}}{2 \text{ m}^3/\text{m}²•\text{d}} = 8.640 \text{ m}² \]

Determine a volumes using OLR equation:
  \[ V = \frac{Q \cdot C_i}{OLR} = \frac{0.2 \text{ m}^3/\text{s} \cdot 86,400 \text{ s/d} \cdot 187 \text{ g/m}³}{300 \text{ g BOD₅/m}³•\text{d}} = 10,771 \text{ m}³ \]

- For domestic wastewater a good rule of thumb:
  - BOD₅ ~ 0.68 BOD₅

Low Rate Rock (cont)

Consider depths and check

- V=Ah or A = V/h
- For h=1 m
- A = 10,771 m²
- Determine HLR
  \[ HLR = 1.6 \text{ m}³/\text{m}²•\text{d} \]
  Within range

- For h = 3 m
- A = 3,590 m²
- Determine HLR
  \[ HLR = 4.8 \text{ m}³/\text{m}²•\text{d} \]
  This is too high, could get scouring
  Choose previous design

Rotating Biological Contactors (RBCs)

- Bacteria grow on plastic disks on rotating shafts
- Bacteria encounter alternating exposure to air and wastewater as it rotates.
Design Loadings

- OLR vary from 0.03 to 0.15 kg BOD$_u$/m$^2$•d (note this is per area not volume)
- HLR usually less than 0.2 m$^3$/m$^2$•d
- Hydraulic detention times of 0.5 hr per stage are typical