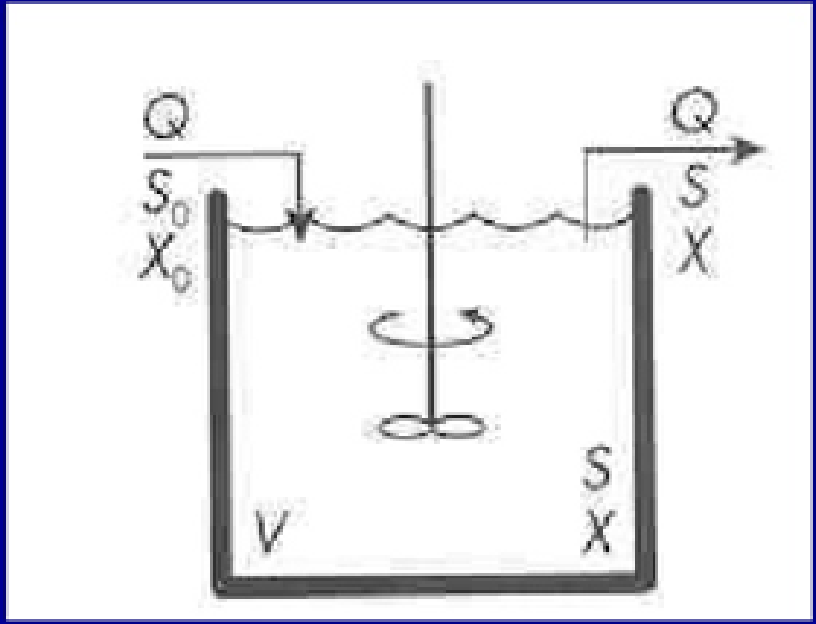
Mean Cell Residence Time(θ_c) or *Solids Retention Time (SRT) or Sludge Age*

Mean cell residence time (MCRT, θ_c) is the mass of cells in the system divided by the mass of cells wasted per day.

Consider the system:



$$\theta_c = VX/QX = V/Q$$

At SS the amount of solids wasted per day must equal the amount produced per day:

$$\theta_c = XV / [Y(dS/dt)V] = X / Y(dS/dt)$$

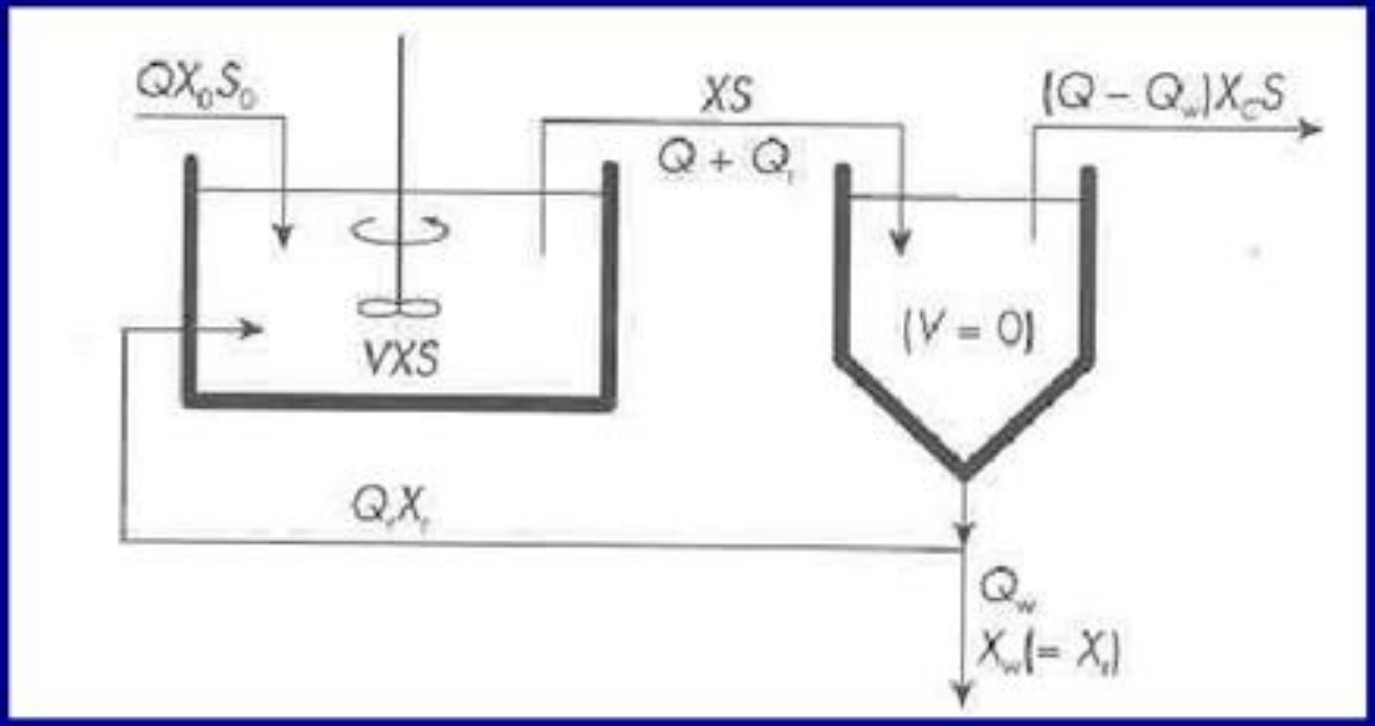
Mean Cell Residence Time(θc) or *Solids Retention Time (SRT)*

- $\theta_c = 1/\mu = 1 / \mu_{max}\ S/(K_S + S)$

  minimal $\theta_c = 1/\mu_{max}$

- SRT typically 4-20 days, HRT usually 6-24 hours

Now consider a CSTR with cell recycle:



Activated sludge process modeling

Mass balance of biomass production

- Influent biomass + biomass production = effluent biomass + sludge wasted

$$Q_o X_o + V\frac{dX}{dt} = (Q_o - Q_w)X_e + Q_w X_w$$

- Substitute biomass production equation

$$Q_o X_o + V\left(\frac{\mu_m S}{K_s + S}\right)X - k_d X = (Q_o - Q_w)X_e + Q_w X_w$$

- Assume that influent and effluent biomass concentrations are negligible and solve

$$\frac{\mu_m S}{K_s + S} = \frac{Q_w X_w}{VX} + k_d$$

Mass balance of food substrate

- Influent substrate + substrate consumed = effluent susbtrate + sludge wasted substrate
- $$Q_o S_o + V\frac{dS}{dt} = (Q_o - Q_w)S_e + Q_w S_w$$
- Substitute substrate removal equation
- $$Q_o S_o + \frac{V}{Y}\left(\frac{\mu_m XS}{K_s + S}\right) = (Q_o - Q_w)S_e + Q_w S_w$$
- Assume that no biochemical action takes place in clarifier. Therefore the substrate concentration in the aeration basin is equal to the substrate concentrations in the effluent and the waste activated sludge. Solve:
- $$\frac{\mu_m S}{K_s + S} = \frac{Q_o Y}{VX}(S_o - S)$$

Overall equations

- Combine the mass balance equations for food and biomass:

$$\frac{Q_w V_w}{VX} + k_d = \frac{Q_o Y}{VX}(S_o - S)$$

The cell residence time is:

$$\theta_c = \frac{VX}{Q_w X_w}$$

and the hydraulic retention time is, $\theta = V/Q_o$

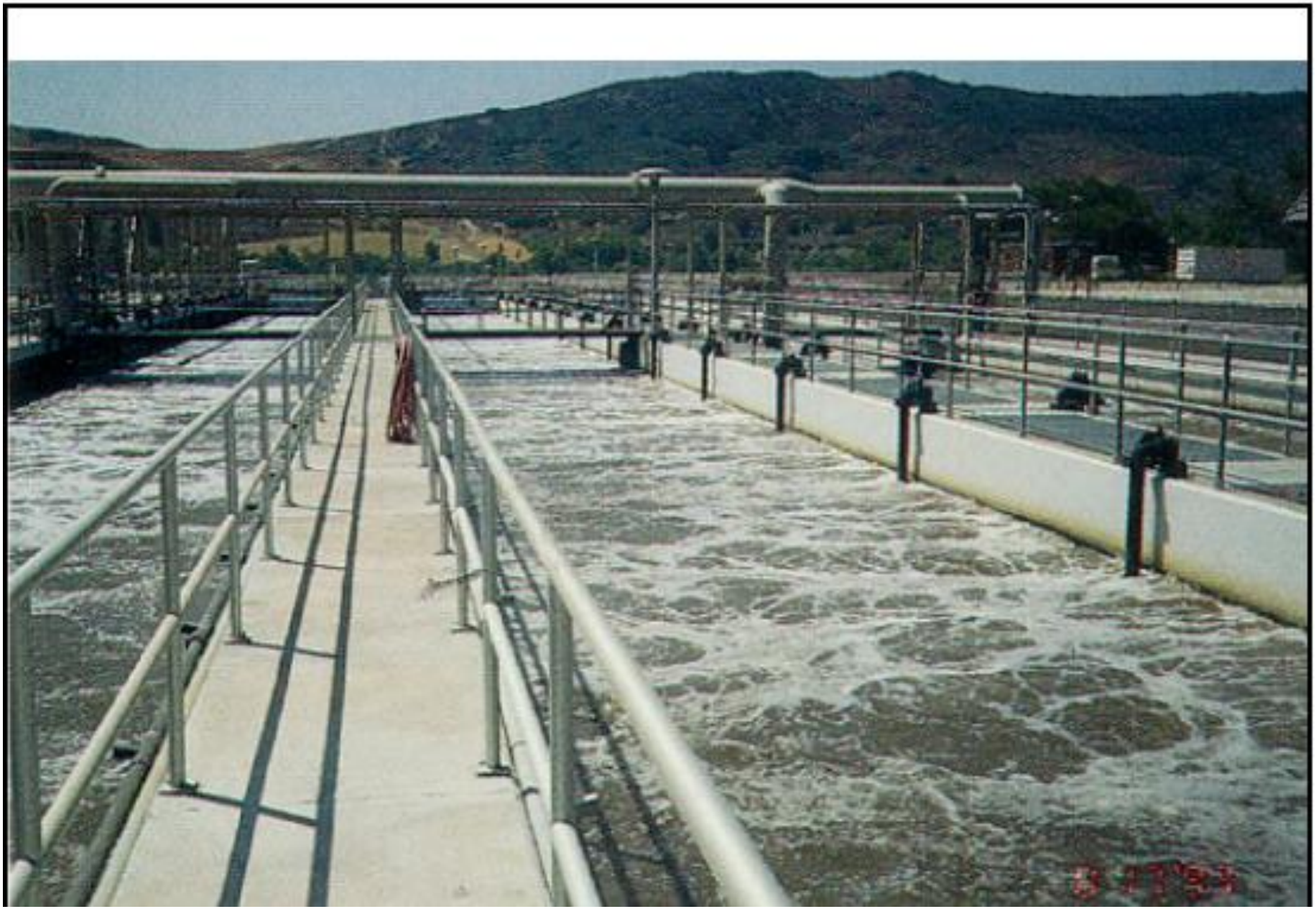
Substitute and rearrange:

$$X = \frac{\theta_c}{\theta} Y \left(\frac{S_o - S}{1 + k_d \theta_c} \right)$$

Compute the F/M ratio

$$\frac{F}{M} = \frac{S_o}{\theta X}$$

$$\frac{F}{M} = \frac{S_o}{(V/Q_o)X} = \frac{Q_o S_o}{VX}$$



Diffusers

What is the definition of MCRT? –

Mean cell residence time –
average time bacteria and solids are in the aeration tank

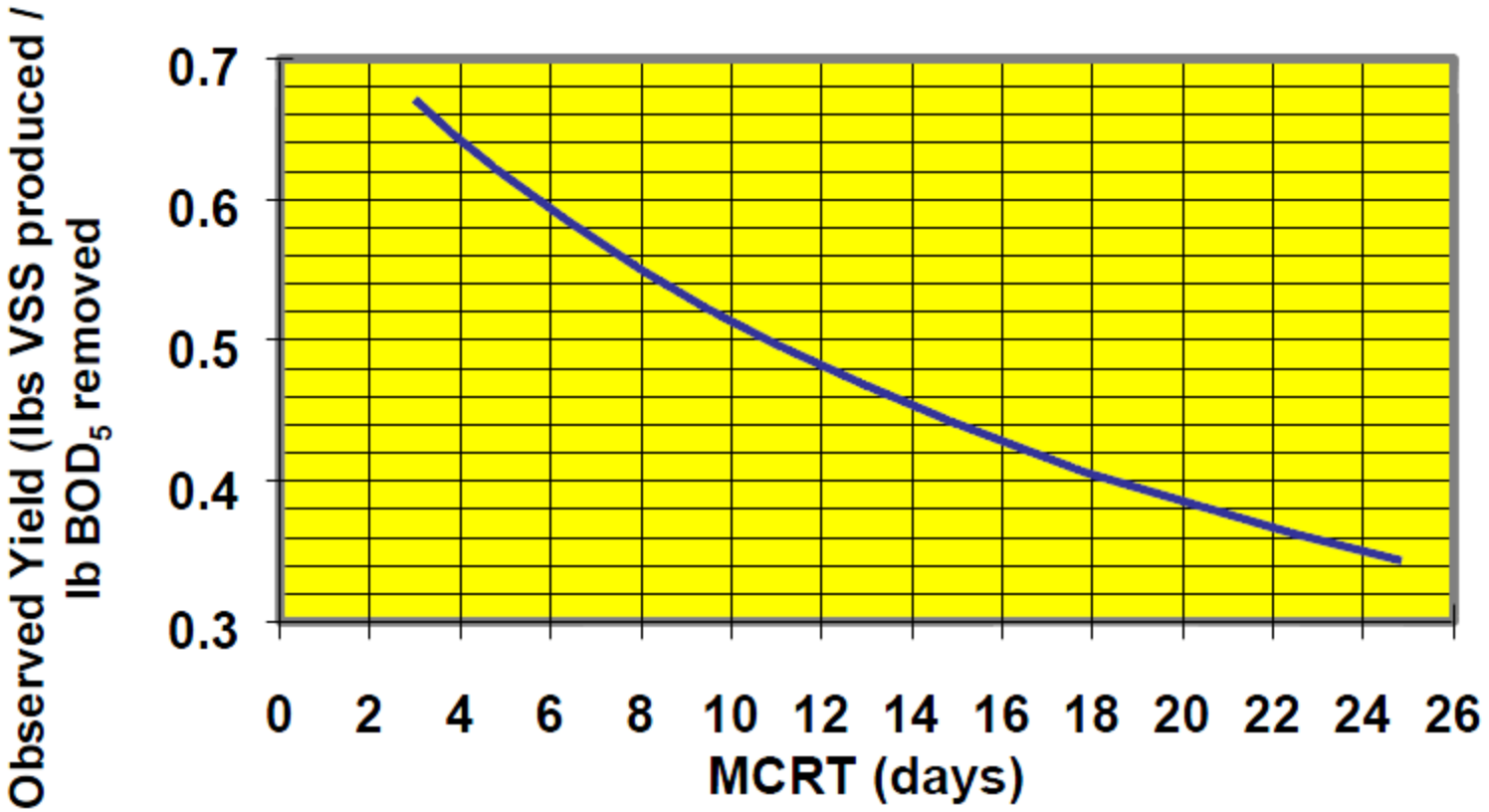
Also more commonly called solids retention time (SRT)

MCRT or SRT =
lbs of solids in reactor or aeration tank divided by the lbs wasted per day
The lbs wasted per day on average equals the lbs produced per day.

If a system has shorter SRT, a larger fraction of its solids are removed per day
Thus less solids in system, less bacteria to consume food
and lower efficiency

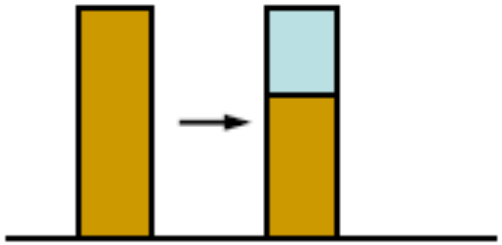
But the removal efficiency is in general only a problem
when the SRT gets below some critical level

Typical VSS Production Versus MCRT



Define SVI and what does it indicate about an activated sludge system?

- SVI is the volume in mL that 1.0 gr (dry weight) of sludge occupies after 30 minutes of settling.
  - Higher SVI means poorer settling
- Example –



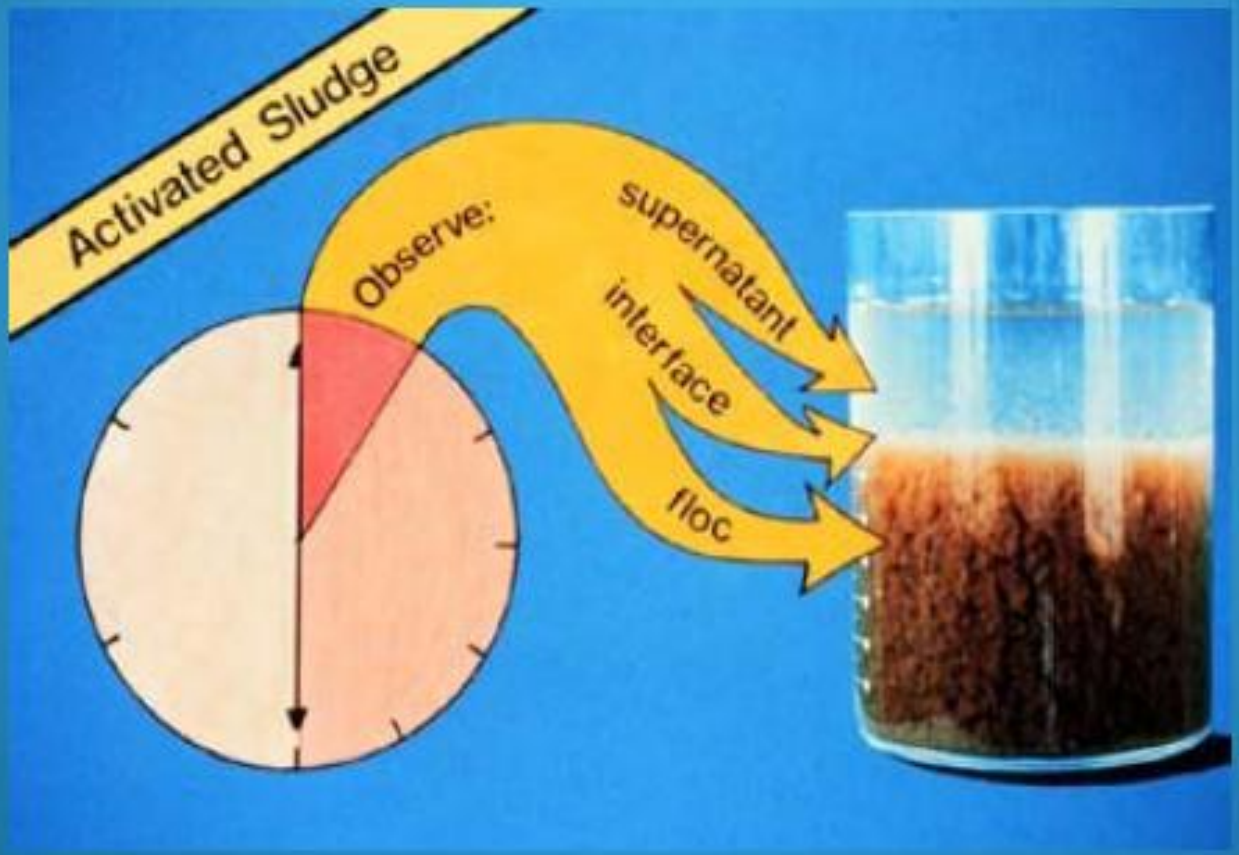
2 liter cylinder

sludge conc. = 3000 mg/L

settled volume at 30 min = 600 mL

SVI = mL/g

Observation of Settlometer Test



Settling Problem in Activated Sludge Processes

Settling well

Settling problem

High Growth of Filaments
Sludge Volume Index > 300 mL/g
Prefer SVI = <150 mL/g