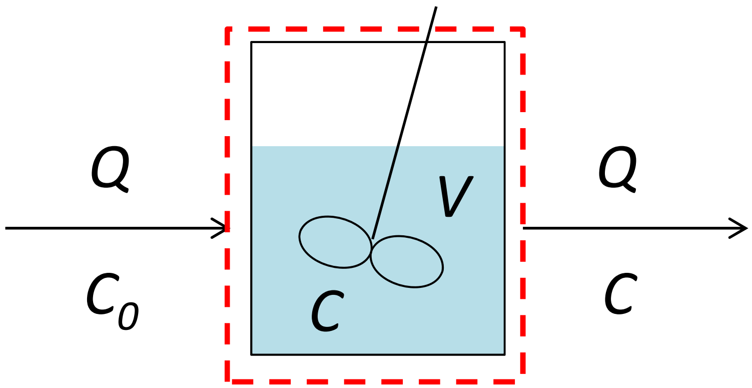
Reactors III

Today's lecture

- Continuous-stirred tank reactor
  - CSTR analysis for 1st order reaction
  - PFR vs. CSTR
  - CSTR analysis for Monod kinetics
- Including inert biomass

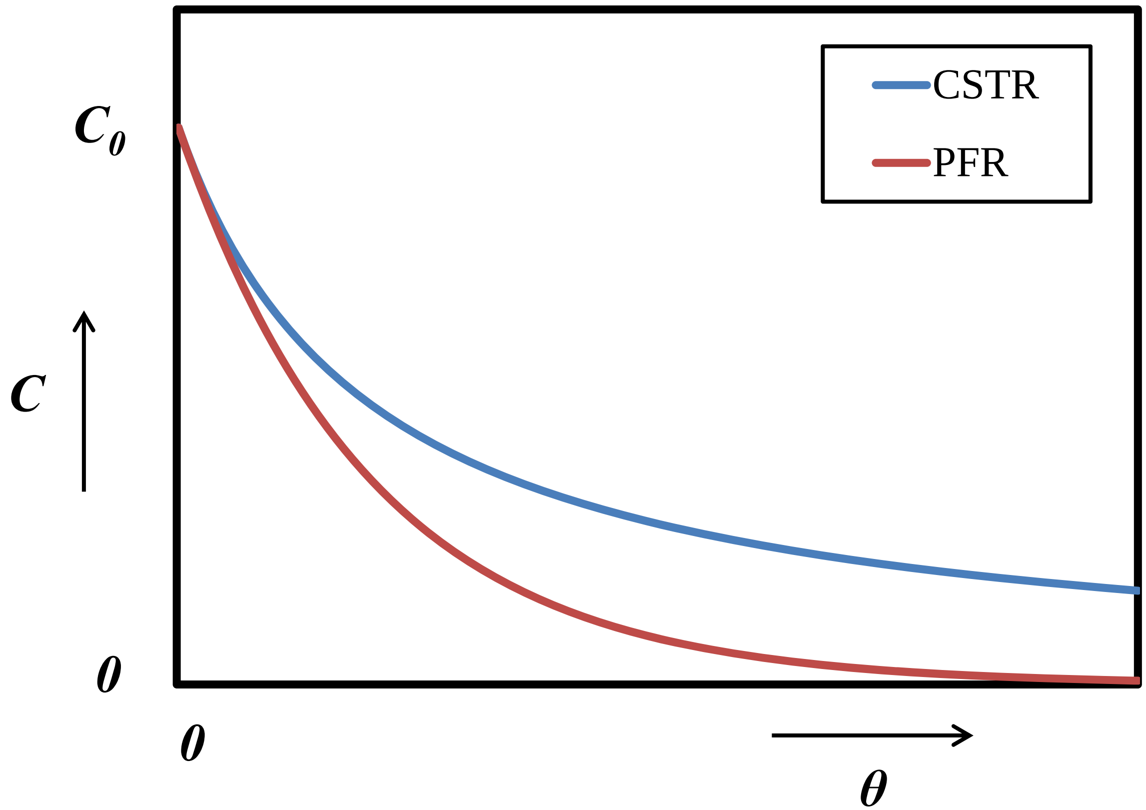
Reactor analysis: CSTR, 1st order



For 1st order reaction of a contaminant,

$$C = \frac{C_0}{1 + k\theta}$$

PFR vs. CSTR



PFR shows better performance esp. at high HRTs

For 1st order reaction,

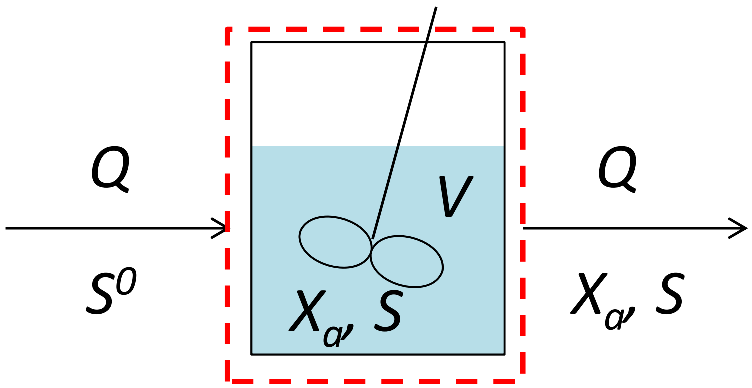
CSTR:

$$C = \frac{C_0}{1 + k\theta}$$

PFR:

$$C = C_0 e^{-k\theta}$$

Reactor analysis: CSTR, Monod kinetics



Assume no active biomass in the influent (negligible)

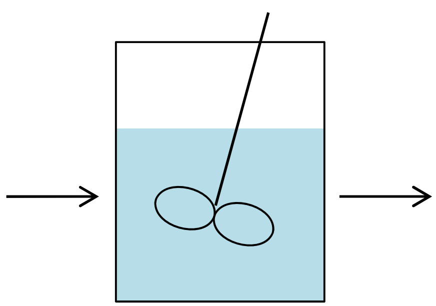
$$S = K \frac{1 + b\theta}{Y\hat{q}\theta - (1 + b\theta)}$$

No S_0 or X_a in the equation!

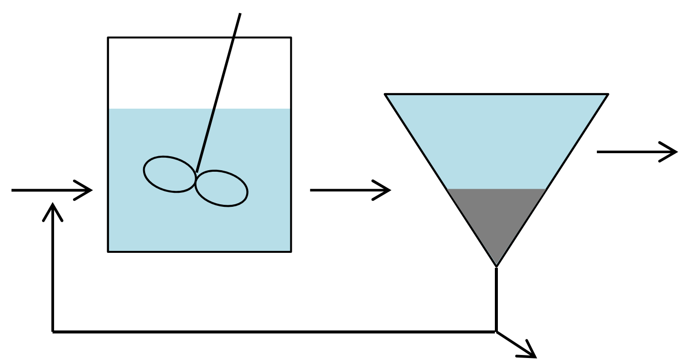
$$X_a = Y \frac{S^0 - S}{1 + b\theta}$$

HRT vs. SRT

- HRT: **H**ydraulic **R**etention **T**ime; the average time the water stays in the system
- SRT: **S**oilds **R**etention **T**ime (or mean cell residence time, MCRT); the average time the biomass stays in the system

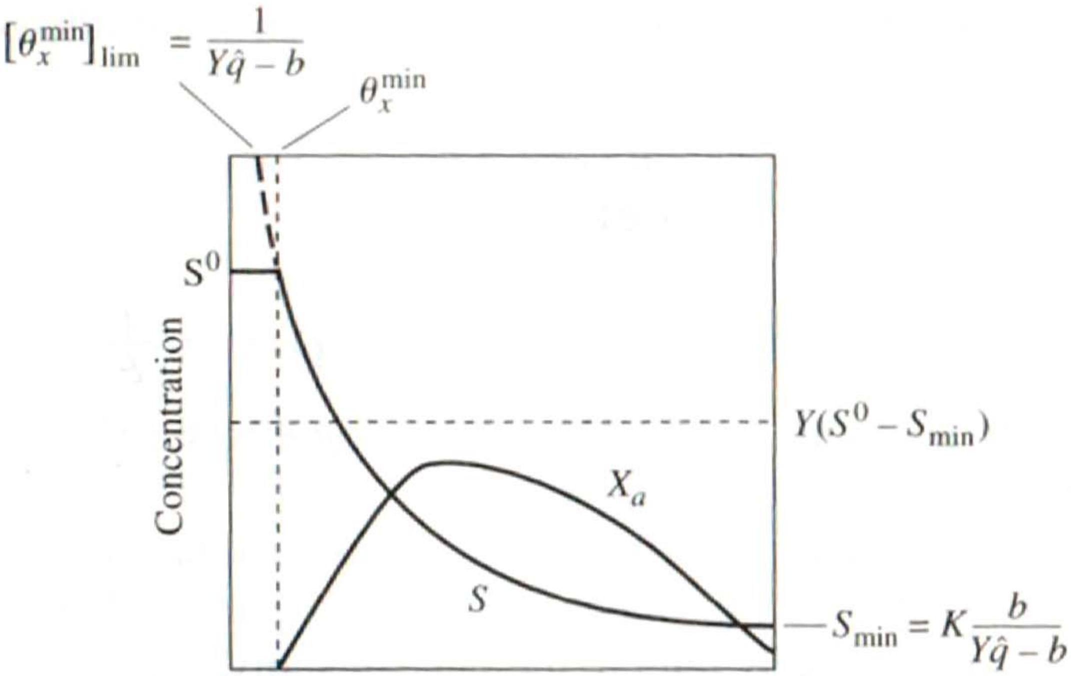


A chemostat: HRT = SRT



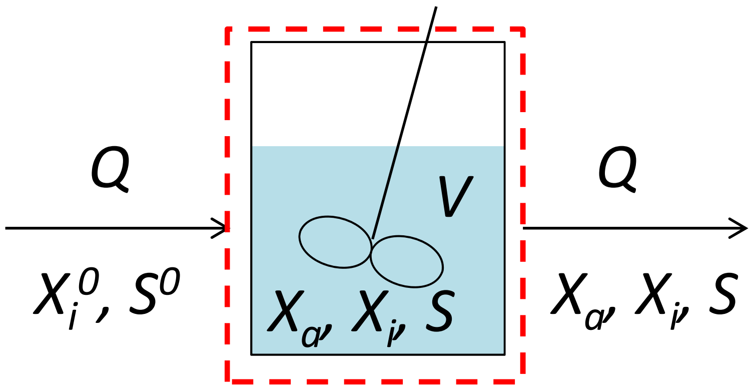
An activated sludge process with sludge return: HRT < SRT

Special cases



1) $\theta_x \leq \theta_{min}$: washout
2) $\theta_x \rightarrow \infty$: $S = S_{min}$
3) For $\theta_{min} < \theta_x$, S decreases with increase in θ_x, but X_a peaks at some point

Including inert biomass

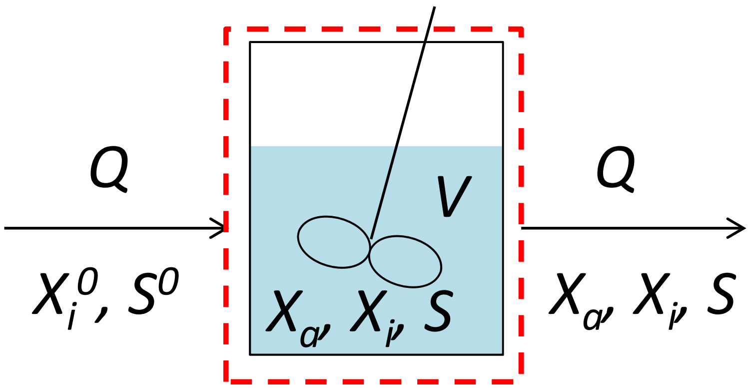


Influent contains some non-biodegradable, particulate organics: this is included when you measure VSS

Recall:

$$\left(\frac{1}{X_a}\frac{dX_a}{dt}\right)_{inert} = -\frac{1}{X_a}\frac{dX_i}{dt} = -(1-f_d)b$$

Including inert biomass



Solution for inert biomass: $X_i = X_i^{\,0} + X_a(1 - f_d)b\theta_x$

Solution for total VSS:

$$X_v = X_i + X_a = X_i^{\,0} + Y\left(S - S^0\right)\frac{1 + (1 - f_d)b\theta_x}{1 + b\theta_x}$$