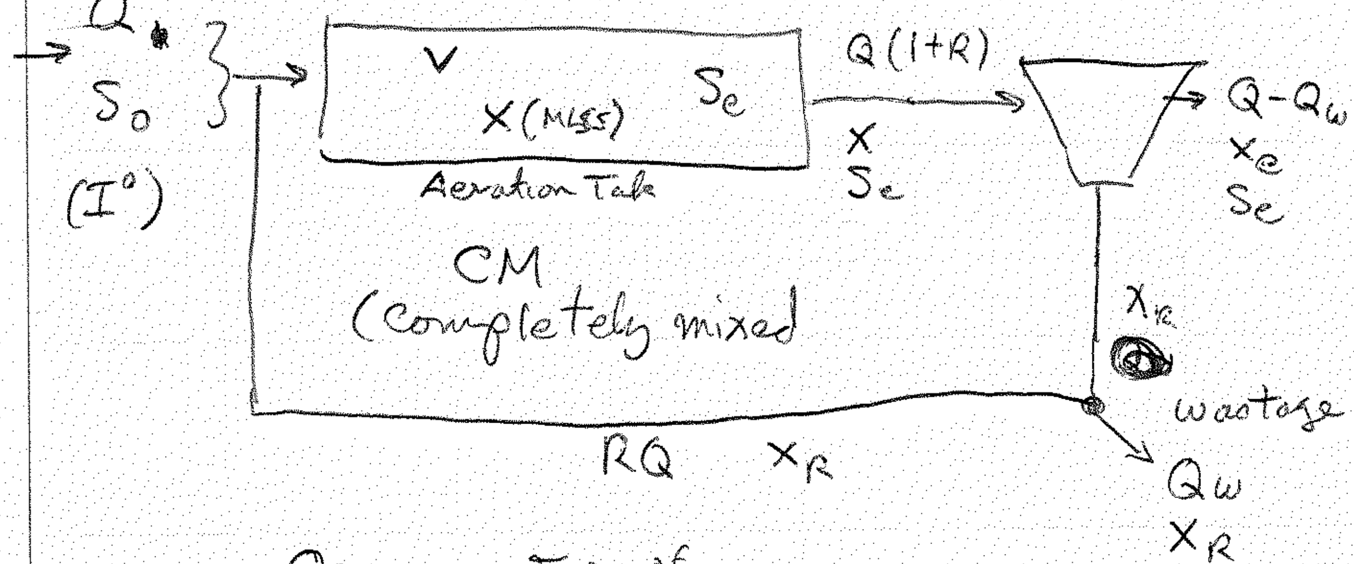
DESIGN OF A II° AERATION BASIN

(1) MLSS ≡ Mixed Liq. S.S. (Filter solids out, dry, weigh)
MLVSS = ML Volatile SS (" " " dry, ash weigh, weigh, report dif)



$R = \frac{Q_R}{Q}$

Type of "continuous culture" OR "Chemostat" ← steady chemical (biol.) composition in basin

(2) TIME SCALES OF INTEREST

(1) Time Water spends in basin

$\Theta = \frac{V}{Q}$ (≡ Hydraul. res. time)

(2) Time CELLS spend in system:

$\Theta_c > \Theta$ iF $R > 0$ Depends on Cell Mass WASTED and mass lost to eff.

~~Rate~~

$$\Theta_c = \frac{\text{Mass of cells}}{\text{Rate of Mass Lost}} = \frac{M}{dM/dt} = \frac{X}{dX/dt}\left(\frac{V}{V}\right)$$

Analogy: LAX Runway: 2 planes on taxi-way
1 departure every 2 min

$$\Theta_p = \frac{X}{dX/dt} = \frac{2 \text{ planes}}{0.5 \text{ pl/min}} = \underline{4 \text{ min}} \text{ WAIT } \underline{\text{on}} \text{ AVERAGE}$$

Increase to 20 plane back-up: $\frac{20}{0.5} = 40$ min wait

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

(3)

More completely

$M_c = VX$

$$\frac{dM_c}{dt} = \underbrace{Q_w X_R}_{\text{waste cell}} + \underbrace{(Q - Q_w)}_{\text{Effluent loss}} X_e$$

$$\boxed{\theta_c = \frac{VX}{Q_w X_R + (Q - Q_w) X_e}}$$ OK... so?

Now look at very interesting fact of chemostats

$$\theta_c = \frac{M_c}{dM_c/dt}$$

$\frac{dM_c}{dt}$ = growth rate of cells (at S.S)

$\frac{dM/dt}{M}$ = specific growth rate

$\equiv \mu$ (net)

(As in $X = X_0 e^{\mu t}$)

$\therefore$ $\boxed{\theta_c = \frac{1}{\mu}}$ so sp. growth rate we control by adjusting θ_c

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(4) $\theta_c \equiv$ "SLUDGE AGE" (age of average cell (sludge))

Can be shown (17.6)

$$\frac{1}{\theta_c} = Y \left(\frac{F}{M}\right) - k_e$$

YIELD FOOD / MICRO.ORG SP. DEATH RATE,

$$\frac{F}{M} = \frac{\text{lbs BOD Removed/day}}{\text{lb MLSS}} \equiv U$$ (units T^{-1} like μ)

↑ (NOT CONC.)

Y = lbs of cells / lb of BOD removed

(5)

SHORT AGE → NO TIME TO EAT → LOTS OF FOOD BUILDS UP

HIGH FOOD CONC → FAST GROWTH (According to Monod)

∴ SHORT AGE ⟺ FAST GROWTH ⟹ $\frac{1}{\theta_c} = \mu$ (OK) ✓

But HIGH FOOD CONC → High Effluent BOD

And we want the "buffet table" to be almost empty when done

"HIGH FOOD" really $\frac{\text{HIGH FOOD CONC}}{\text{CELL}} = \frac{F}{M}$

So High F/M → Fast growth, lousy effluent

Also: "fat" cells, bulky sludge, poor settling

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(6) WANT: ~ SLOW GROWTH → OK SINCE THEY SPEND A LONG "SLUDGE AGE" IN TANK

⟹ Low Growth ⟷ Low F/M → LOW EFFLUENT BOD

(According to Monod)

We really control this by MINIMIZING WASTAGE

→ LONG SLUDGE AGE

5-15 DAYS

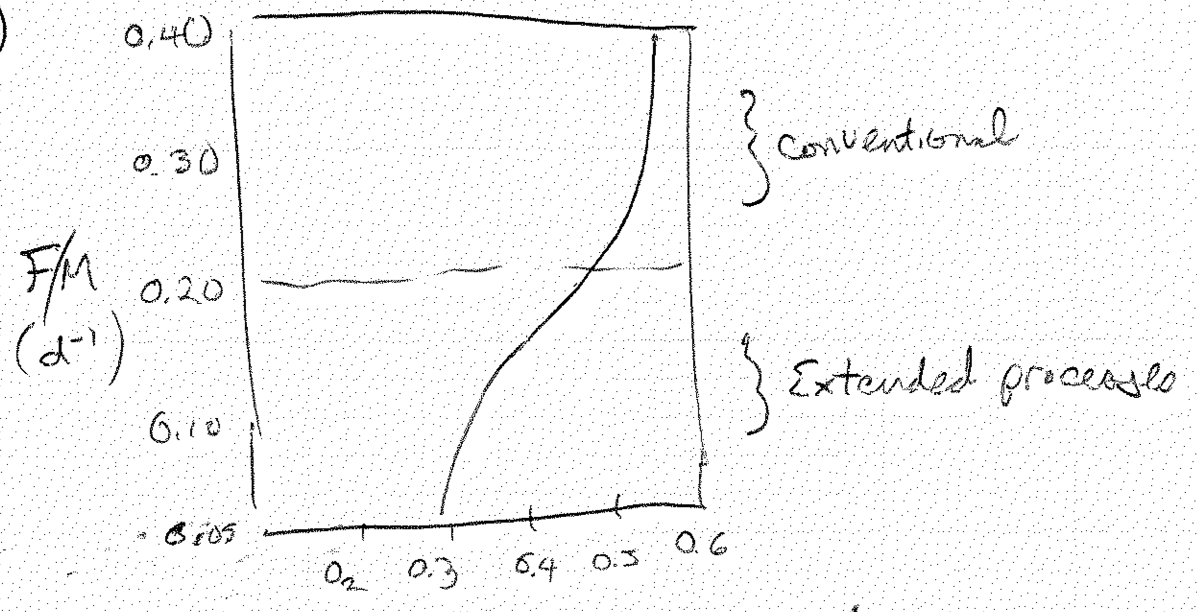
Compared to 0.25 - 0.5 day HRT

Long sludge age, long time at "Buffet"

↳ Nothing much left → Low S_e (< 30 mg/L BOD)

We force the bugs to "clean their plates" just like your mom did: stay at table til you're done

(7)



$k \equiv$ lb of SS growth / lb BOD applied

(@ YIELD, really)

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(8) Process of Design

(1) SIZE TANK: check (A) $\frac{BOD/d}{1000\,ft^3/}$ $\Rightarrow V_1$

(B) DETENTION TIME $\Rightarrow V_2$

CHOOSE THE LARGER (V)

(2) Pick an F/M, find MLSS ← (Choose F/M based on type of process. E.g., above chart says minimum F/M for "Conventional" is about 0.2)

$\frac{\text{lb BOD/d}}{XV} \Rightarrow$ (X) ← solve for MLSS

(3) Find θ_c (or θ_x using book notation)

$$\frac{XV}{Q_w X_R + (Q - Q_w) X_e}$$

(X_e = TSS of II° clarifier effluent. EPA says $X_e \leq 30$ mg/L, so assume 30 mg/L)

9 (4) Find your recycle rate

$$r = \frac{1 - \frac{\theta_d}{\theta_x}}{\frac{X_r}{X} - 1}$$ ← All parameters now known

(5) Size your II° clarifier based on recommend surf. loading rates