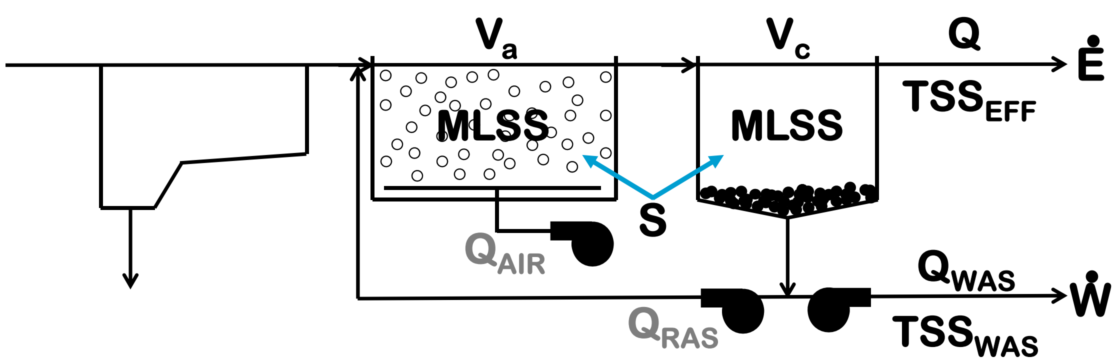
Problem of the Day

2014.Oct.04

Discussion

In the 2014.Oct.01 Problem of the Day, the food-to-microorganism ratio was briefly discussed. Most state certification exams require operators to be able to calculate the F/M ratio and to use it to determine how many pounds of biomass, or "microorganisms," are needed in the aeration basin for the amount of BOD, or "food," per day that is entering the aeration basin. **The reality is, contrary to what readers will hear from almost everybody except WWTT, neither operators nor engineers control the amount of biomass in an activated sludge system, the microbes do**. Absolutely, positively, the most important activated sludge control parameter is the mean cell residence time (MCRT) or the mathematically similar solids residence time (SRT). While many will preach that activated sludge operators have to "keep an eye on many parameters like the MCRT (or SRT), the MLSS concentration, the MLVSS concentration, the system mass, and the F/M ratio," **please, please, please understand that all of these are controlled by the MCRT**. Besides controlling these, the MCRT also controls sludge quality and whether or not the activated sludge system will nitrify.

The following schematic summarizes the information needed to calculate and control the MCRT.



Activated sludge process schematic

Problem

The MCRT, or SRT, is the **most important** parameter that an activated sludge operator controls.

Problem of the Day: There is a total aeration basin volume of 1.85 Mgal at the Levee Road WWTP. The total secondary clarifier volume is 0.65 Mgal. Influent flow to the plant is 5.5 MGD. The TSS concentrations in the mixed liquor (MLSS), WAS and effluent are 1,650, 4,400 and 9.8 mg/L, respectively. Currently, the WAS flow rate averages 0.12 MGD. Calculate the MCRT.

Solution

It is helpful to list the information given in the problem statement:

- Q = 5.5 Mgal/d
- TSS_{EFF} = 9.8 mg TSS/L
- Q_{WAS} = 0.12 Mgal/d
- TSS_{WAS} = 4,400 mg TSS/L
- V_a = 1.85 Mgal
- V_c = 0.65 Mgal
- $V_a + V_c$ = 2.5 Mgal
- MLSS = 1,650 mg MLSS/L

Under the pressure of a certification exam, operators tend to "freak out" when it comes to MCRT calculations. The main reason for this is because there are so many computations to do. Just remember: all you're doing is three pounds calculations.

WWTT recommends that each pounds calculation been done separately. Referring to the schematic on the previous page, these are:

$\dot{E}$ = **pounds per day** of TSS unintentionally lost in the **E**ffluent

$\dot{W}$ = **pounds per day** of TSS intentionally removed in the **W**AS

S = **pounds** of MLSS in the **S**ystem (aeration basin + secondary clarifier)

The "dot" in $\dot{E}$ and $\dot{W}$ (called "E dot" and "W dot," respectively) signifies that both of these are in units of **pounds per day** (i.e., they are **rates** of solids removal), whereas the absence of a dot over the S indicates this is in units of **pounds**. From a solids "accounting" standpoint, it is much easier for the operator to break down MCRT calculations into these three components: $\dot{E}$, $\dot{W}$ and S. The calculations are defined in "equation railroad tracks" as follows:

$$\left|\frac{\dot{E}\text{ lb TSS}}{\text{d}}\right| = \left|\frac{TSS_{EFF}\ \cancel{\text{mg}}\text{ TSS}}{\cancel{\text{L}}}\right|\frac{\cancel{\text{L}}}{\cancel{\text{M}\cdot\text{mg}}}\left|\frac{Q\ \cancel{\text{Mgal}}}{\text{d}}\right|\frac{8.34\text{ lb}}{\cancel{\text{gal}}}\right|$$

$$\left|\frac{\dot{W}\text{ lb TSS}}{\text{d}}\right| = \left|\frac{TSS_{WAS}\ \cancel{\text{mg}}\text{ TSS}}{\cancel{\text{L}}}\right|\frac{\cancel{\text{L}}}{\cancel{\text{M}\cdot\text{mg}}}\left|\frac{Q_{WAS}\ \cancel{\text{Mgal}}}{\text{d}}\right|\frac{8.34\text{ lb}}{\cancel{\text{gal}}}\right|$$

$$\left|\text{S lb MLSS}\right| = \left|\frac{\text{MLSS}\ \cancel{\text{mg}}\text{ MLSS}}{\cancel{\text{L}}}\right|\frac{\cancel{\text{L}}}{\cancel{\text{M}\cdot\text{mg}}}\left|\frac{(V_a+V_c)\ \cancel{\text{Mgal}}}{}\right|\frac{8.34\text{ lb}}{\cancel{\text{gal}}}\right|$$

Once $\dot{E}$, $\dot{W}$ and S have been determined using these equations, the MCRT is easily calculated:

$$\left|\text{MCRT d}\right| = \left|\frac{\text{S}\ \cancel{\text{lb MLSS}}}{}\right|\frac{\text{d}}{(\dot{E}+\dot{W})\ \cancel{\text{lb TSS}}}\right|$$

It is important to note that the State of California, on its wastewater treatment plant operator certification exams, assumes that if you could pick up the secondary clarifier and mix the sludge blanket solids throughout the secondary clarifier volume, then the solids concentration would equal the MLSS concentration. There are different techniques used to calculate the mass of solids in secondary clarifiers. The SRT calculation, for example, assumes the mass of solids in the secondary clarifiers is minimal (that is, sludge blankets are kept to a minimum), so they are not even included in the calculation. The State of

California's assumption might not be the most accurate. Nevertheless, it is presented here as this is the approach California wants operators to use on certification exams.

Repeating the problem statement:

Problem of the Day: There is a total aeration basin volume of 1.85 Mgal at the Levee Road WWTP. The total secondary clarifier volume is 0.65 Mgal. Influent flow to the plant is 5.5 MGD. The TSS concentrations in the mixed liquor (MLSS), WAS and effluent are 1,650, 4,400 and 9.8 mg/L, respectively. Currently, the WAS flow rate averages 0.12 MGD. Calculate the MCRT.

$\dot{E}$, $\dot{W}$ and S are calculated using the equation railroad tracks given above.

$$\frac{\dot{E}\text{ lb TSS}}{\text{d}} = \frac{9.8\ \cancel{\text{mg}}\text{ TSS}}{\cancel{\text{L}}} \cdot \frac{\cancel{\text{L}}}{\cancel{\text{M}\cdot\text{mg}}} \cdot \frac{5.5\ \cancel{\text{Mgal}}}{\text{d}} \cdot \frac{8.34\text{ lb}}{\cancel{\text{gal}}}$$

The arithmetic: $\dot{E}$ = 9.8 x 5.5 x 8.34 = 450 lb TSS/d.

$$\frac{\dot{W}\text{ lb TSS}}{\text{d}} = \frac{4{,}400\ \cancel{\text{mg}}\text{ TSS}}{\cancel{\text{L}}} \cdot \frac{\cancel{\text{L}}}{\cancel{\text{M}\cdot\text{mg}}} \cdot \frac{0.12\ \cancel{\text{Mgal}}}{\text{d}} \cdot \frac{8.34\text{ lb}}{\cancel{\text{gal}}}$$

The arithmetic: $\dot{W}$ = 4,400 x 0.12 x 8.34 = 4,404 lb TSS/d

$$\text{S lb MLSS} = \frac{1{,}650\ \cancel{\text{mg}}\text{ MLSS}}{\cancel{\text{L}}} \cdot \frac{\cancel{\text{L}}}{\cancel{\text{M}\cdot\text{mg}}} \cdot (1.85+0.65)\ \cancel{\text{Mgal}} \cdot \frac{8.34\text{ lb}}{\cancel{\text{gal}}}$$

The arithmetic: S = 1,650 x 2.5 x 8.34 = 34,402 lb MLSS.

With $\dot{E}$, $\dot{W}$ and S known, the MCRT calculation is very straightforward using the equation railroad track given above:

$$\text{MCRT d} = \frac{34{,}402\ \cancel{\text{lb MLSS}}}{} \cdot \frac{\text{d}}{(450 + 4{,}404)\ \cancel{\text{lb TSS}}}$$

= <u>7.1 d</u>.

Notice in this last railroad track that lb MLSS was canceled with lb TSS. It is important to understand that the MLSS is the TSS in the mixed liquor, so MLSS and TSS are the same thing. This should give you no hesitation.

Again, the MCRT, or SRT, is the most important parameter that an activated sludge operator controls.