Problem of the Day

2015.Jun.28

Problem of the Day

The plant flow is 1.3 MGD. The aeration basin has a volume of 450,000 gallons. The two secondary clarifiers have a total volume of 130,000 gallons. The lead operator maintains a wintertime MCRT of 7.5 days to nitrify and have good sludge and effluent quality (the SVI is 95 mL/g and the effluent TSS is 8 mg/L). The MLSS concentration is 2,600 mg/L. Calculate the WAS flow to maintain the MCRT in gallons per day. The TSS concentration of the WAS is 8,400 mg/L.

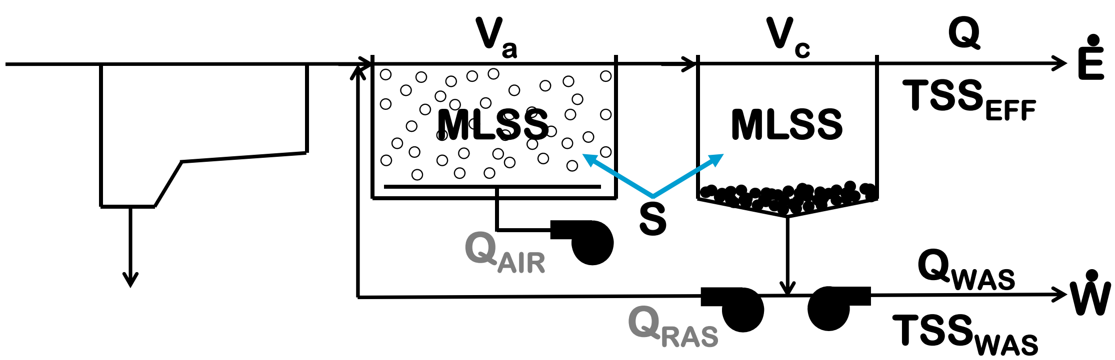
Introduction

In numerous Problems of the Day, the food-to-microorganism (F:M) ratio has been discussed and calculated. 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," **you should 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

Solution

Under the pressure of a certification exam, operators tend to "freak out" when it comes to MCRT calculations. In fact, generally speaking, most operators do not control their activated sludge systems with MCRT because . . . because . . . I'm not sure why. Maybe it's because there is too much to calculate. Just remember: all you're doing is pounds calculations and, in today's problem, a reverse pounds equation. And know, too, again, absolutely, positively, the most important activated sludge control parameter is the MCRT or the mathematically similar SRT.

WWTT recommends in problems dealing with the MCRT that each pounds calculation been done separately. Referring to the schematic, these are:

> **Ė** = **pounds per day** of TSS unintentionally lost in the **E**ffluent
>
> **Ẇ** = **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 Ė and Ẇ (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: Ė, Ẇ and S.

From a practical standpoint, it is a much more commonplace calculation to determine what the WAS flow has to be in order to maintain a target MCRT, as in today's problems. The calculations we need to perform to do so are defined in "equation solution bridges" as follows:

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

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

$$\frac{\dot{W}\ \textbf{lb TSS}}{\textbf{d}} = \frac{S\ \textbf{lb MLSS}}{MCRT_{target}\ \textbf{d}} - \frac{\dot{E}\ \textbf{lb TSS}}{\textbf{d}}$$

As it pertains to the calculation of S, it is important to note that the State of California, on its wastewater treatment plant operator certification exams, assumes that if you could mix the sludge blanket solids throughout the secondary clarifier volume, then the solids concentration in the secondary clarifier 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 minimal), so only the mass of solids in the aeration basin(s) is included in the SRT 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.

In order to do this problem, we have to do each of the calculations given in the solution bridges above and then calculate the WAS flow knowing the WAS TSS concentration.

Problem of the Day: The plant flow is 1.3 MGD. The aeration basin has a volume of 450,000 gallons. The two secondary clarifiers have a total volume of 130,000 gallons. The lead operator maintains a wintertime MCRT of 7.5 days to nitrify and have good sludge and effluent quality (the SVI is 95 mL/g and the effluent TSS is 8 mg/L). The MLSS concentration is 2,600 mg/L. Calculate the WAS flow to maintain the MCRT in gallons per day. The TSS concentration of the WAS is 8,400 mg/L.

The following list summarizes the information given expressed in the appropriate units:

1. Q = 1.3 Mgal/d
2. TSS_{EFF} = 8 mg TSS/L
3. Target MCRT = 7.5 d
4. V_a = 450,000 gal = 0.45 Mgal
5. V_c = 130,000 gal = 0.13 Mgal
6. $V_a + V_c$ = 0.58 Mgal
7. MLSS = 2,600 mg MLSS/L
8. SVI = 95 mL/g
9. WAS TSS = 8,400 mg TSS/L

Ė, S and Ẇ are calculated using the equation solution bridges given above.

$$\frac{\dot{E}\ \text{lb TSS}}{\text{d}} = \frac{8\ \cancel{mg}\ \text{TSS}}{\cancel{L}} \cdot \frac{\cancel{L}}{\cancel{M \cdot mg}} \cdot \frac{1.3\ \cancel{Mgal}}{\text{d}} \cdot \frac{8.34\ \text{lb}}{\cancel{gal}}$$

The arithmetic: Ė = 8 x 1.3 x 8.34 = 86.7 lb TSS/d.

S lb MLSS	=	2,600 ~~mg~~ MLSS	~~L~~	(0.45 + 0.13) ~~Mgal~~	8.34 lb
		~~L~~	~~M·mg~~		~~gal~~

The arithmetic: S = 2,600 x 0.58 x 8.34 = 12,577 lb MLSS.

$\dot{W}$ lb TSS	=	12,577 lb MLSS		−	86.7 lb TSS
d			7.5 d		d

The arithmetic: $\dot{W}$ = (12,577 ÷ 7.5) − 86.7 = 1,590 lb TSS/d.

These are the pounds of TSS per day that have to be wasted. Now we have to do a reverse pounds equation to calculate the WAS flow in the requested units gal/d. To start the solution bridge, the pounds of TSS per day is entered to get d in the denominator as needed in the answer.

gal	=	1,590 lb TSS	
d		**d**	

The unit TSS is canceled by entering the WAS TSS concentration in the denominator.

gal	=	1,590 lb ~~TSS~~	L	
d		**d**	8,400 mg ~~TSS~~	

The units mg/L are canceled using one of WWTT's favorite conversion factors.

gal	=	1,590 lb ~~TSS~~	~~L~~	M·~~mg~~	
d		**d**	8,400 ~~mg~~ ~~TSS~~	~~L~~	

Since we don't have an Mgal to cancel the M in the numerator, a conversion factor is used.

gal	=	1,590 lb ~~TSS~~	~~L~~	~~M·mg~~	10^6 **gal**	
d		**d**	8,400 ~~mg~~ ~~TSS~~	~~L~~	~~M~~gal	

Finally, to cancel the lb and the gal, the density of water is entered in the denominator.

gal	=	1,590 ~~lb~~ ~~TSS~~	~~L~~	~~M·mg~~	10^6 **gal**	~~gal~~
d		**d**	8,400 ~~mg~~ ~~TSS~~	~~L~~	~~Mgal~~	8.34 ~~lb~~

Since all units have now canceled except those needed in the answer, the solution bridge is complete. The arithmetic gives the answer.

Problem of the Day: The plant flow is 1.3 MGD. The aeration basin has a volume of 450,000 gallons. The two secondary clarifiers have a total volume of 130,000 gallons. The lead operator maintains a wintertime MCRT of 7.5 days to nitrify and have good sludge and effluent quality (the SVI is 95 mL/g and the effluent TSS is 8 mg/L). The MLSS concentration is 2,600 mg/L. Calculate the WAS flow to maintain the MCRT in gallons per day. The TSS concentration of the WAS is 8,400 mg/L.

gal	=	1,590 ~~lb~~ ~~TSS~~	~~L~~	~~M·mg~~	10^6 **gal**	~~gal~~
d		**d**	8,400 ~~mg~~ ~~TSS~~	~~L~~	~~Mgal~~	8.34 ~~lb~~

1,590 x 1,000,000 ÷ 8,400 ÷ 8.34 = **22,696 gal/d**.

Discussion

As I have said, this is the most important calculation activated sludge operators make because **the MCRT, or SRT, is the most important parameter that an activated sludge operator controls**.

Happy calculating! Let us know, by leaving a comment, if you want us to do a specific problem, if you see a mistake, or if you have a question on any of the Problems of the Day you are looking at.