Problem of the Day

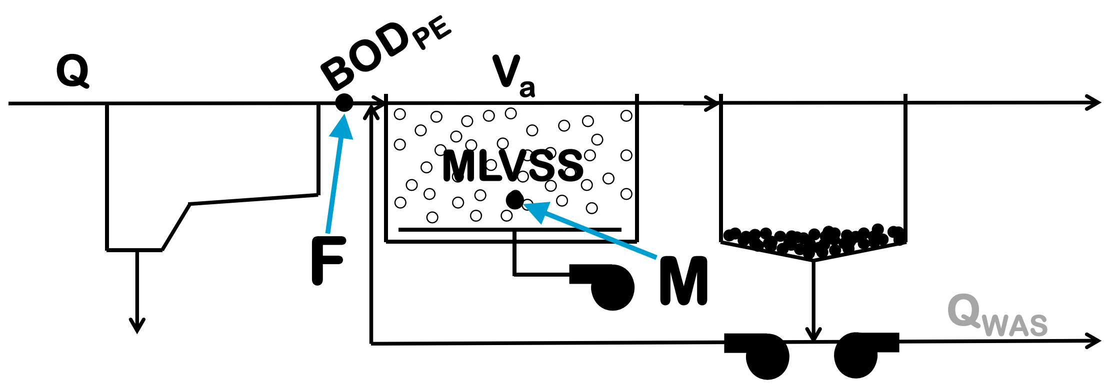
2014.Oct.14

Discussion

In the Problem of the Day on 2014.Oct.04, the importance of the MCRT, or the mathematically similar SRT, to activated sludge process control was stressed. That post ended with, "**Again, the MCRT, or SRT, is the most important parameter that an activated sludge operator controls**." While many books, training materials, trainers, instructors, what have you, 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**. All of this can be proven mathematically. Besides controlling these, the MCRT also controls sludge quality (how the activated sludge flocculates, settles and compacts in the secondary clarifier) and whether or not the activated sludge system will nitrify.

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 "microorganisms" are needed in the aeration basin for the amount of BOD, or "food," per day that is entering the aeration basin. **Remember: neither operators nor engineers control the amount of biomass in an activated sludge system, the microbes do**. Still, we have to be able to calculate F/M and use it to "control" the activated sludge process, so today's Problem of the Day demonstrates the calculation. In the Problem of the Day on 2014.Oct.05, the F/M was calculated. Today, we will use the F/M to calculate what the MLSS concentration should be in the aeration basin.

The following schematic summarizes the information needed to calculate and control the F/M.



Activated sludge process schematic showing needed information to calculate the F/M ratio

Problem

The MCRT, or SRT, is the **most important** parameter that an activated sludge operator controls, but you need to be able to work with F/M, too. For the exams, not in real life....

Problem of the Day: The operator at the Running Springs extended aeration activated sludge plant has found from experience that good sludge and effluent quality result when the F/M ratio is kept at 0.15. If the influent flow to the plant is 0.9 MGD with a BOD concentration of 275 mg/L (no primary clarifiers), what MLSS concentration should she target if the MLSS are 74% volatile and the aeration basin volume is 1.2 MG.

Solution

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

- Influent Q = 0.9 Mgal/d
- BOD_{INF} = 275 mg BOD/L
- No primary clarifiers
- Target F/M = 0.15 lb BOD/d·lb MLVSS (**these are the units on the F/M ratio**)
- V_a = 1.2 Mgal
- 74% MLVSS = 74 lb MLVSS/100 lb MLSS

The F/M ratio is just two pounds calculations. Most of the time the F/M ratio is reported as if it does not have units associated with it. This is completely false. **The units on the F/M ratio are lb BOD/d•lb MLVSS**.

WWTT recommends that F and M be calculated separately. Again, these are defined as follows:

F = **pounds per day** of BOD entering the aeration basin

M = **pounds** of MLVSS

The F and M calculations are defined in "equation railroad tracks" as follows:

F **lb BOD**	=	BOD_{INF} ~~mg~~ **BOD**	~~L~~	Q ~~Mgal~~	8.34 **lb**
d		~~L~~	~~M·mg~~	**d**	~~gal~~

M **lb MLVSS**	=	**MLVSS** ~~mg~~	~~L~~	V_a ~~Mgal~~	8.34 **lb**
		~~L~~	~~M·mg~~		~~gal~~

But in this problem, we don't know the MLVSS concentration and we're solving for the MLSS concentration. So the strategy is to calculate F first, a straightforward pounds-per-day calculation.

F **lb BOD**	=	275 ~~mg~~ **BOD**	~~L~~	0.9 ~~Mgal~~	8.34 **lb**
d		~~L~~	~~M·mg~~	**d**	~~gal~~

F = 2,064 lb BOD/d.

This is then used to find the answer, but first the solution is started with the units the question asks for between heavy vertical lines followed by the equals sign and the blank railroad track.

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mg MLSS	=	
L		

As discussed in a previous Problems of the Day, whenever the question asks to solve for concentration in either mg/L or ppM, the railroad track is **always** started with the conversion factor, M·mg/L. The reason for this is because it gets mg and L, needed in the answer, in the railroad track.

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mg MLSS	=	M·**mg**	
L		**L**	

WWTT enters the unit, MLSS, in the railroad track next. From the list of information above, MLSS is given as a unit in only one instance, so it is entered into the railroad track in the numerator where it is needed in the answer.

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mg MLSS	=	M·**mg**	100 lb **MLSS**	
L		**L**	74 lb MLVSS	

As indicated by **bold**, all of the units needed in the answer are now in the railroad track. Continuing with the problem requires the cancelation of all unwanted units. (Canceling units in the railroad track is more fun than a video game!)

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mg MLSS	=	M·**mg**	100 lb **MLSS**	d·~~lb MLVSS~~	
L		**L**	74 ~~lb MLVSS~~	0.15 lb BOD	

The units, lb BOD, do not show up in the list above. What is entered into the railroad track next is the F calculated above. Entering this into the railroad track cancels lb BOD and d.

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mg MLSS	=	M·**mg**	100 lb **MLSS**	~~d·lb MLVSS~~	2,064 ~~lb BOD~~	
L		**L**	74 ~~lb MLVSS~~	0.15 ~~lb BOD~~	~~d~~	

The M will be canceled by the M in Mgal, but we have two Mgals in the list above. But, we've already used one in the calculation of F, so we enter the aeration basin volume in the railroad track so the Ms cancel.

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mg MLSS	=	~~M~~·**mg**	100 lb **MLSS**	~~d·lb MLVSS~~	2,064 ~~lb BOD~~		
L		**L**	74 ~~lb MLVSS~~	0.15 ~~lb BOD~~	~~d~~	1.2 ~~M~~gal	

At this point, the only remaining, unwanted units in the railroad track are lb and gal. These are canceled by entering the density of water.

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mg MLSS	=	~~M~~·**mg**	100 ~~lb~~ **MLSS**	~~d·lb MLVSS~~	2,064 ~~lb BOD~~		~~gal~~
L		**L**	74 ~~lb MLVSS~~	0.15 ~~lb BOD~~	~~d~~	1.2 ~~Mgal~~	8.34 ~~lb~~

The railroad track only contains the units desired, so the math is complete. The arithmetic gives the answer:

100 x 2,064 ÷ 74 ÷ 0.15 ÷ 1.2 ÷ 8.34 = **1,858 mg MLSS/L**.

So, let's talk about this problem**.** FIrst, it is very important to remember that even though the F/M ratio was given in the problem statement with no units**, the F/M is NOT without units; the units on the F/M ratio are lb BOD/d•lb MLVSS**. Second, the F/M given in this problem is lower than "typical." This is because, as stated in the problem, this is an extended aeration activated sludge system, which are typically characterized by low F/M ratios and are different in other respects when compared to the other modes of the activated sludge system. But how much sense does it make to control by the F/M ratio? Without going into a long discussion about the fact that both the MLSS and MLVSS concentrations are **response** variables not control variables, it doesn't make any sense, at least not to me, to think that the BOD coming into my plant today is going to be the same as it was five or six days ago when the influent BOD sample was collected. In fact, this doesn't make any sense at all! Any operator who has ever worked in municipal wastewater treatment knows that the BOD concentration and flow into a plant are constantly changing season after season, day after day, hour after hour, even minute after minute. We cannot know at any given instant how many pounds of BOD per day are entering our treatment plants. But that's okay, because **the microbes know and they will grow the right number of organisms for the amount of BOD entering the aeration basin**. We don't control the amount of microbes, the microbes do. We need to stop thinking otherwise.