Problem of the Day

2015.Dec.05

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The chief plant operator of the plant in the last two days' Problems of the Day abandoned F:M control long ago. She currently targets an SRT of 6.5 days because it gives good sludge quality and it fully nitrifies. It is late summer and the MLSS concentration in the six on-line aeration basins has dropped to 980 mg/L. Each aeration basin holds 2.2 Mgal. She wants to increase the MLSS concentration while keeping the SRT at the current target. Calculate what the MLSS concentration would be if she takes one of the aeration basins off line.

Introduction

As discussed the last two days, the wastewater operations profession now knows that the solids retention time (SRT), or it's close mathematical cousin the mean cell residence time (MCRT), is the most important activated sludge control and design parameter. By controlling the SRT (MCRT), operators and engineers control the growth rate of the microorganisms in the activated sludge system. Further, the profession knows that for a given SRT (MCRT), a given BOD (or COD) load, a given inorganic TSS load, and a given wastewater temperature, the mass of solids in an activated sludge system, biological plus inorganic, is fixed.

Fixed.

It doesn't matter if that mass is in six aeration basins or five, **the pounds will be the same**. What changes when that mass is in six or five aeration basins is the concentration, which is what today's problem is asking. This is very important for operators to understand. It is also worth noting that very few operator texts will tell you that the mass of solids in an activated sludge system is primarily fixed once the SRT (MCRT) is set by the operator. We have to get away from the idea that we control the M in the F:M ratio. We don't, the microorganisms do because they know exactly how many microorganisms can be supported by the incoming organic load given the growth rate we impose on them by controlling the SRT (MCRT).

The CPO in today's problem wants to keep the SRT constant while she takes an aeration basin off line. This highlights another very important operational strategy for all activated sludge operators: whenever an aeration basin and/or a secondary clarifier is taken off line, you want to keep the solids in that tank(s) in the system. **You do NOT want to send the solids to waste**. The reason? If the solids are wasted, the system will have to re-grow all them. Remember: For a given SRT (MCRT), a given BOD (or COD) load, a given inorganic TSS load, and a given wastewater temperature, the mass of solids in an activated sludge system, biological plus inorganic, is fixed.

Solution

As I worked through this problem, I was weighted down by a serious dilemma. As you know if you've been following Problems of the Day of recent, I've introduced a new labeling convention. Unfortunately, that new convention doesn't work so well in today's problem. It works okay, it just doesn't work as elegantly as I'd like; it's not as straightforward. If you know me, you know I hate being inconsistent, especially when teaching math to operators. Inconsistency causes confusion. Confusion is the root cause, in my opinion, of operators' fear of math. I hate doing this to you, but I have to go back to my old way, at the center of which is my favorite conversion factor that says a liter of water weighs a million milligrams and expressed as:

$$\frac{\text{M·mg}}{\text{L}}$$

Or, as necessary:

$$\frac{\text{L}}{\text{M·mg}}$$

("Hello old friend. Really good to see you once again.")

On first glance, you might not think the question gives enough information to do the problem. But knowing that the total mass of solids will be the same whether it's in six aeration basins or five, tells us most of what we need to know. We can calculate the mass of MLSS in the six aeration basins with a straightforward pounds calculation:

lb MLSS	=	980 ~~mg~~ **MLSS**	8.34 **lb**	~~L~~	2.2 ~~Mgal~~	6 ~~AB~~
		~~L~~	~~gal~~	~~M·mg~~	~~AB~~	

980 × 8.34 × 2.2 × 6 = **<u>107,886 lb MLSS</u>**.

With this, the information given, calculated and assumed is listed:

1. Mass of MLSS in system = 107,886 lb MLSS (calculated)
2. Number of aeration basins (AB) = 5 AB
3. Volume of each = 2.2 Mgal/AB
4. Density of mixed liquor = 8.34 lb/gal (assumed since not given)

Today's problem asks to calculate the MLSS concentration (mg MLSS/L) after one aeration basin is taken off line. These units, then, are put between heavy vertical lines, as always, followed by an equals sign and the blank solution bridge.

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mg MLSS	=	
L		

Whenever a problem asks to calculate the concentration of anything in mg/L, the solution bridge will always be started with M·mg/L. Always. Doing so gets mg and L in the numerator and denominator of the solution bridge as needed in the answer, shown in bold.

mg MLSS	=	M·**mg**	
L		**L**	

We now need the units MLSS on the solution bridge. These units occur in the list only in No. 1, which we calculated above, so it is entered to get the units needed in the numerator of the answer as shown in bold.

mg MLSS	=	M·**mg**	107,886 lb **MLSS**	
L		**L**		

All the units needed in the answer are now on the solution bridge. To proceed, unwanted units are canceled. One option is to cancel the M by entering the volume, in Mgal, of each aeration basin in the denominator of the solution bridge. Remember, whenever the word "per" comes across you lips ("2.2 Mgal **per** AB") you jump across the bridge.

mg MLSS	=	~~M~~·**mg**	107,886 lb **MLSS**	AB	
L		**L**		2.2 ~~M~~gal	

Next, the units AB are canceled by entering in the denominator of the solution bridge the number of on-line aeration basins, now 5 instead of the original 6, No. 2 in the list.

mg MLSS	=	~~M~~·**mg**	107,886 lb **MLSS**	~~AB~~		
L		**L**		2.2 ~~M~~gal	5 ~~AB~~	

The remaining units, lb and gal, are both canceled by entering the density of the mixed liquor in the solution bridge, No. 4.

mg MLSS	=	~~M~~·**mg**	107,886 ~~lb~~ **MLSS**	~~AB~~		~~gal~~
L		**L**		2.2 ~~Mgal~~	5 ~~AB~~	8.34 ~~lb~~

Since all the units have now canceled except those needed in the answer, **mg MLSS/L**, we know the solution bridge is complete. The arithmetic gives the answer.

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mg MLSS	=	~~M~~·**mg**	107,886 ~~lb~~ **MLSS**	~~AB~~		~~gal~~
L		**L**		2.2 ~~Mgal~~	5 ~~AB~~	8.34 ~~lb~~

107,886 ÷ 2.2 ÷ 5 ÷ 8.34 = **1,176 mg MLSS/L**.

Discussion

You probably recognize this problem as a "reverse" pounds equation. I know there are piecharts that will tell you how to set up such calculations but you have to memorize the piecharts. Just let the units tell you what to do.

Obviously, there is a much easier way to do this problem:

(980 mg/L) × 6 ~~AB~~/5 ~~AB~~ = **1,176 mg MLSS/L**.

Doing it this way, though, misses the point and that is that the pounds of MLSS in the system remains constant whether those pounds are in 6 aeration basins or 5 aeration basins. What is the MLSS concentration in 4 aeration basins? I know and now you do, too.

One more thing: To quote a verse from Lau-tzu's *Tao Te Ching* (*Book of the Way*):

A great nation is like a great man:
When he makes a mistake, he realizes it.
Having realized it, he admits it.
Having admitted it, he corrects it.
He considers those who point out his faults
as his most benevolent teachers.
He thinks of his enemy
as the shadow that he himself casts.

Please excuse my inconsistencies of the recent past.

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.