Problem of the Day

2015.Dec.03

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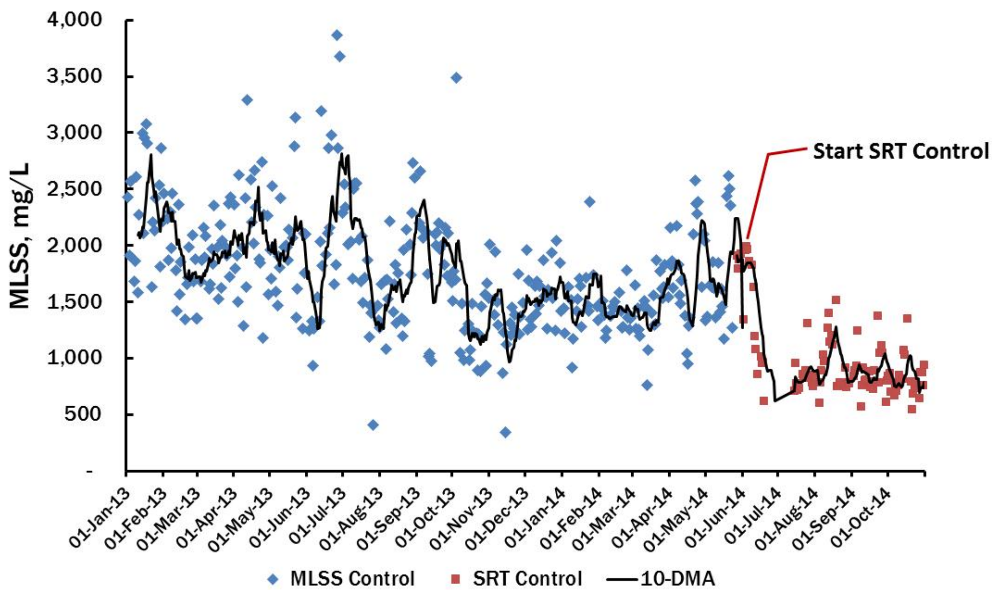
How many pounds of mixed liquor volatile suspended solids (MLVSS) are in six aeration basins, each holds 2.2 Mgal and all are in service. The MLSS concentration is 2,150 mg/L. The mixed liquor is 74.4% volatile.

Introduction

The wastewater treatment operations profession uses MLVSS as a measure of the microorganisms in the mixed liquor. The pounds of MLVSS in the aeration basin(s) is the M (microorganisms) in the food-to-microorganisms (F:M) ratio.

As a bit of an aside, I would like to make two comments before we work the solution to today's Problem of the Day. First, perhaps the most significant wrong that has been perpetuated in the activated sludge training materials used for decades and still used today for certification exam questions is the notion that operators and engineers control the amount of biomass in an activated sludge system. While it may have been a reasonable and workable idea back when we didn't fully understand microbiological growth and substrate utilization, we have learned a lot in the last 20 to 30 years. We now know that the solids residence time (SRT), or it's close mathematical cousin the mean cell residence time (MCRT), is the most important control and design parameter because by controlling it, operators and engineers control the growth rate of the microorganisms in the activated sludge system. Further, we know that for a given SRT (or MCRT), a given BOD (or COD) load (i.e., concentration × flow), a given inorganic TSS load, and wastewater temperature, the mass of solids, biological plus inorganic, in an activated sludge system is fixed. Fixed. The BOD load to an activated sludge system, lb BOD/d, is the F in the F:M ratio. To reiterate what was just said and ignoring the inorganic TSS load to the system: for a given SRT (or MCRT), a given F (i.e., BOD or COD load), and wastewater temperature, the M will be fixed. The simplest way to think about this is that the microorganisms know exactly how many microorganisms can be supported by the incoming organic load. Controlling the M in an activated sludge system does not work well as seen in the following graphic. Bottom line: operators and engineers should control all activated sludge treatment plants using SRT (MCRT) and let the microorganisms "control" the M.



MLSS concentration in the first stage of a large, two-stage (BOD removal followed by ammonia oxidation) activated sludge plant in the Midwest during two phases of control: (1) control by maintaining a target MLSS concentration ("MLSS Control") and (2) control by maintaining a target SRT ("SRT Control"). Note the lack of control of the MLSS concentration when the MLSS concentration was supposedly being controlled! (Note: 10-DMA = 10-day moving average.)

Second, in the advanced-treatment volume of the most widely used training manuals in the United States, I am puzzled by a section that addresses volatile solids inventory. In that section, there is the contention made that the situation may arise when the volatile content of the mixed liquor is different than the volatile content in the return activated sludge (RAS). How can that be? If the RAS is just settled mixed liquor, by what mechanism would the volatile content (I am assuming percent VSS) change during settling? I am constantly amazed—stunned in some cases—by what is presented in operator training documents and, even more so, the fact that as we learn more, the profession doesn't update the training documents!

Solution

The following information is given in the problem statement or assumed. Note the manner in which I have modified the way I express mg/L and others. The expressions I have used (for example, “Mixed liquor (ML)” are not unique nor do they need to be memorized. As you get used to doing problems like this, you can use whatever expressions make the most sense to you. Just remember, label things as completely and understandably as possible.

1. Number of aeration basins (AB) = 6 AB
2. Mixed liquor (ML) volume per aeration basin = 2.2 Mgal ML/AB
3. ML density = 8.34 lb ML/gal ML (assumed since not given)
4. MLSS concentration = 2,150 mg MLSS/L = 2,150 lb MLSS/M lb ML (this is ppM)
5. MLVSS concentration = 74.4% = 74.4 lb MLVSS/100 lb MLSS

Today’s problem asks to calculate lb MLVSS in the aeration basins. 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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$$\left|\ \text{lb MLVSS}\ \right| = \underline{\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad}$$

The only place the units lb MLVSS appear in the list given above is in the numerator of No. 5. This, then, is entered to start the solution bridge to get the units needed in the answer as shown in bold. You should know that if something is presented by itself and not as a fraction, like “lb MLVSS” here, it is understood to be over 1 and, therefore, in the numerator.

$$\left|\ \textbf{lb MLVSS}\ \right| = \frac{74.4\ \textbf{lb MLVSS}}{100\ \text{lb MLSS}}$$

The solution bridge contains the units needed in the answer. The next step, then, is to cancel unwanted units. The MLSS concentration given as parts per million parts instead of mg/L (No. 4) is entered so the units lb MLSS cancel in the denominator and numerator.

$$\left|\ \textbf{lb MLVSS}\ \right| = \frac{74.4\ \textbf{lb MLVSS}}{100\ \cancel{\text{lb MLSS}}} \cdot \frac{2{,}150\ \cancel{\text{lb MLSS}}}{\text{M lb ML}}$$

The density of the mixed liquor, No. 3, is entered to cancel the units lb ML in the denominator and numerator. Don’t mix up the M in ML and the M for million, but even if you do, all the units will cancel out.

$$\left|\ \textbf{lb MLVSS}\ \right| = \frac{74.4\ \textbf{lb MLVSS}}{100\ \cancel{\text{lb MLSS}}} \cdot \frac{2{,}150\ \cancel{\text{lb MLSS}}}{\text{M}\ \cancel{\text{lb ML}}} \cdot \frac{8.34\ \cancel{\text{lb ML}}}{\text{gal ML}}$$

The volume of each aeration basin is entered, No. 2, to cancel the units Mgal ML in the denominator and numerator.

lb MLVSS	=	74.4 **lb MLVSS**	2,150 ~~lb MLSS~~	8.34 ~~lb ML~~	2.2 ~~Mgal ML~~	
		100 ~~lb MLSS~~	~~M lb ML~~	~~gal ML~~	AB	

Finally, the unit AB is canceled by entering the number of on-line aeration basins.

lb MLVSS	=	74.4 **lb MLVSS**	2,150 ~~lb MLSS~~	8.34 ~~lb ML~~	2.2 ~~Mgal ML~~	6 ~~AB~~
		100 ~~lb MLSS~~	~~M lb ML~~	~~gal ML~~	~~AB~~	

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

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lb MLVSS	=	74.4 **lb MLVSS**	2,150 ~~lb MLSS~~	8.34 ~~lb ML~~	2.2 ~~Mgal ML~~	6 ~~AB~~
		100 ~~lb MLSS~~	~~M lb ML~~	~~gal ML~~	~~AB~~	

74.4 × 2,150 × 8.34 × 2.2 × 6 ÷ 100 = **<u>176,000 lb MLVSS</u>** (rounded).

Discussion

Sometimes people complain that including all these units are a waste of time. My question to our readers is simple: Is getting the correct answer on a certification exam worth a little time?

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.