Problem of the Day

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Find the F:M ratio at a plant that has a flow of 1.3 MGD and an influent BOD of 325 mg/L. There are no primary clarifiers. The oxidation ditch has a volume of 1.85 million gallons. The MLSS concentration is 3,200 mg/L and is 78% volatile.

Introduction

Very often the F:M ratio is given without units. The fact of the matter is, however, that the F:M ratio is not a pure ratio meaning it has units. I don't know why so many people in our business don't put units on the F:M ratio. The units are pounds of BOD per day per pound of MLVSS under aeration, lb BOD/d·lb MLVSS. For operators doing math problems on certification exams, using these units will greatly simplify calculations dealing with the F:M ratio.

Solution

The units, although not identified in the problem statement, are lb BOD /d·lb MLVSS, as just discussed. These units are entered between heavy vertical lines, as always, followed by an equals sign and the blank solution bridge.

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$$\left|\frac{\text{lb BOD}}{\text{d·lb MLVSS}}\right| = \frac{\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad}{}$$

The following list summarizes the information given in the problem statement expressed in the appropriate units (note the calculation of the MLVSS concentration in No. 6):

1. Plant flow = 1.3 Mgal/d
2. Influent BOD concentration = 325 mg BOD/L
3. Aeration basin (oxidation ditch) volume = 1.85 Mgal
4. MLSS concentration = 3,200 mg MLSS/L
5. Percent MLVSS = 78% = 0.78
6. MLVSS concentration = 0.78 x 3,200 = 2,496 mg MLVSS/L

Typically, I would calculate F first (lb BOD/d), then calculate M (lb MLVSS), then divide F by M. Instead, I'm just going to let the units tell me what to do. I want to start the solution bridge out with the units BOD in the numerator and MLVSS in the denominator. I get these from No. 2 and No. 6, respectively, in the list of information. Both of these units are needed in the answer so are shown in bold on both sides of the equals sign. By doing this, notice that mg and L cancel out, numerator and denominator.

$$\left|\frac{\text{lb } \mathbf{BOD}}{\text{d·lb } \mathbf{MLVSS}}\right| = \frac{325\ \cancel{\text{mg}}\ \mathbf{BOD} \quad \cancel{\text{L}}}{\cancel{\text{L}} \quad 2{,}496\ \cancel{\text{mg}}\ \mathbf{MLVSS}}$$

Next, I need days (d) in the denominator and the only information in the list that has days in it is the flow so this is entered.

$$\left|\frac{\text{lb } \mathbf{BOD}}{\mathbf{d}\text{·lb } \mathbf{MLVSS}}\right| = \frac{325\ \cancel{\text{mg}}\ \mathbf{BOD} \quad \cancel{\text{L}} \quad 1.3\ \text{Mgal}}{\cancel{\text{L}} \quad 2{,}496\ \cancel{\text{mg}}\ \mathbf{MLVSS} \quad \mathbf{d}}$$

I can cancel the unwanted Mgal in the numerator by entering the oxidation ditch volume in the denominator.

$$\left|\frac{\text{lb } \mathbf{BOD}}{\mathbf{d}\text{·lb } \mathbf{MLVSS}}\right| = \frac{325\ \cancel{\text{mg}}\ \mathbf{BOD} \quad \cancel{\text{L}} \quad 1.3\ \cancel{\text{Mgal}}}{\cancel{\text{L}} \quad 2{,}496\ \cancel{\text{mg}}\ \mathbf{MLVSS} \quad \mathbf{d} \quad 1.85\ \cancel{\text{Mgal}}}$$

Now, all the units needed in the answer are on the solution bridge except the lb in the numerator and denominator. I think everyone would agree that if I multiplied any calculation by 1 lb/1 lb, it wouldn't change the calculation at all since this is just the number 1. So that's what I do here. Since all the units have now canceled except those needed in the answer, we know the solution bridge is complete. The arithmetic gives the answer.

lb BOD	=	325 ~~mg~~ **BOD**	~~L~~	1.3 ~~Mgal~~		1 **lb**
d·lb MLVSS		~~L~~	2,496 ~~mg~~ **MLVSS**	**d**	1.85 ~~Mgal~~	1 **lb**

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lb BOD	=	325 ~~mg~~ **BOD**	~~L~~	1.3 ~~Mgal~~		1 **lb**
d·lb MLVSS		~~L~~	2,496 ~~mg~~ **MLVSS**	**d**	1.85 ~~Mgal~~	1 **lb**

325 x 1.3 ÷ 2,496 ÷ 1.85 = **0.09 lb BOD/d·lb MLVSS**.

Discussion

The range of F:M "ratios" for extended aeration activated sludge systems, like an oxidation ditch, is 0.05 to 0.15 lb BOD/d·lb MLVSS, so our answer looks very reasonable. But what about the way we went about calculating it on the solution bridge? Also completely reasonable since the units worked out. The units always have to work out. If the units don't work, you can't get the correct answer.

If you were to do this problem more "traditionally" (I suggest you try), you should find that F equals 3,524 lb BOD/d, and M equals 38,511 lb MLVSS. Then:

3,524 ÷ 38,511 = **0.09 lb BOD/d·lb MLVSS**.

As it should!

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.