Problem of the Day
2014.Dec.04

Introduction

We're still keeping with pounds calculations.

Every operator should know how to calculate pounds and pounds per day given concentration (in mg/L or ppM). We will call both calculations the "pounds calculation."

There are two elements that have to come together for the pounds calculation to work. First, volume—whether it's volume to calculate pounds or volume/time (that's flow) to calculate pounds per day—has to be converted to Mgal (million gallons). We can do this very easily in the railroad track so there is no need to convert the volume to Mgal before working the railroad track; in fact, WWTT recommends against doing this conversion "on the side." Second and the reason for the first, is there is an embedded M (million) in mg/L and, of course, ppM (parts per million parts). If concentration is given in ppM, WWTT recommends it be expressed as mg/L because in our business **mg/L = ppM**. This conversion factor tells us why that's so:

$$\frac{M \cdot mg}{L} \quad \text{or} \quad \frac{L}{M \cdot mg}$$

Today's and several previous days' Problems of the Day demonstrate.

For those of you who may be new to WWTT's Problem of the Day, we insert a page break before and after the problem statement so you can print it without looking at the solution. **See what you can do to solve the problem before looking at the solution**.

Problem of the Day

How many pounds of BOD per day are in the primary effluent flowing to the aeration basins if the primary influent BOD concentration is 265 mg/L and 37.5% of the influent BOD is removed in the primary clarifiers. Flow to the plant is 840 gpm.

Discussion

Key words and information: "**How many pounds**" and "**mg/L**." You **know** you're going to be using the "pounds calculation."

I can't tell you how often we calculate pounds and pounds per day in the wastewater treatment business. We do these calculations over and over and over again. Doing them should be second nature to all operators. No matter how comfortable you are doing these calculations, WWTT recommends you always carry the units **all the way through** so you don't forget anything. Today's problem is another good example of "there's a lot going on here." Remember: units are your friend and they will tell you how to do a problem in almost all instances. Practice the problems with the units. It will pay off huge.

One has to think carefully about this piece of information given in the problem: "... 37.5% of the influent BOD is removed in the primary clarifiers." If 37.5% is removed, what percentage of BOD is not removed and passes into the primary effluent? A very simple calculation: 100% − 37.5% = 62.5%. This is important as the primary influent BOD concentration given will need to be "adjusted" by this amount to take account of the BOD that is removed in the primary clarifier.

Solution

We're not given any information in the problem with Mgal in it, but we know we can convert gal/min (gpm) to Mgal. To begin, we put the units we want the answer to be in, **lb BOD/d**, between heavy vertical lines followed by an equals sign and the blank track.

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Information summary, specifically labeled:

- Plant flow = 840 gal/min
- Primary influent BOD = 265 mg BOD/L
- Percent BOD passing through primary clarifiers = 62.5% = 0.625 (from above)
- **Calculate: pounds of BOD per day (lb BOD/d) in primary effluent**.

$$\left|\frac{\text{lb BOD}}{\text{d}}\right| = \text{———————————————}$$

The unit, **BOD**, needed in the answer only shows up in the list of information given in the problem in one other place, 265 mg **BOD**/L. Entering influent BOD concentration starts the railroad track.

$$\left|\frac{\text{lb } \mathbf{BOD}}{\text{d}}\right| = \left|\frac{\text{265 mg } \mathbf{BOD}}{\text{L}}\right| \text{———————}$$

The BOD concentration just entered into the railroad track is the primary **influent** concentration and we need the primary **effluent** concentration. To get the effluent concentration, we have to multiply by the percent BOD that **passes through**, not removed, the primary clarifier expressed as a decimal.

$$\left|\frac{\text{lb } \mathbf{BOD}}{\text{d}}\right| = \left|\frac{\text{265 mg } \mathbf{BOD}}{\text{L}}\right| \left|\frac{\text{0.625}}{\text{}}\right| \text{———————}$$

Whenever mg/L are entered into the railroad track, WWTT recommends they be canceled with the conversion factor, **M•mg/L**, unless the problem is solving for mg/L.

lb **BOD**	=	265 ~~mg~~ **BOD**	0.625	~~L~~	
d		~~L~~		M~~mg~~	

The M that remains in the denominator is a reminder that an Mgal is needed in the numerator to cancel the Ms, as discussed at the beginning of this post. But there is no Mgal in the information given in the problem. What do we do? We use the conversion factor, **Mgal/10^6 gal**, to enter the Mgal needed. Notice, too, that gal cancels in the numerator and denominator.

lb **BOD**	=	265 ~~mg~~ **BOD**	0.625	~~L~~	~~Mgal~~	
d		~~L~~		~~M~~mg	10^6 ~~gal~~	

It looks like we're in trouble because we've canceled all the units in the railroad track except **BOD**. But we still need **lb** in the numerator of the answer so it has to be entered in the railroad track. We do this by entering the density of water. Notice that the unit, **lb**, has to go in the numerator.

lb BOD	=	265 ~~mg~~ **BOD**	0.625	~~L~~	~~Mgal~~	8.34 **lb**	
d		~~L~~		~~M~~mg	10^6 ~~gal~~	gal	

Now we have the units needed in the numerator of the answer, **lb BOD**, but we've added, and need to cancel, **gal**, in the denominator. We do this by entering the plant flow into the railroad track so **gal** cancel.

lb BOD	=	265 ~~mg~~ **BOD**	0.625	~~L~~	~~Mgal~~	8.34 **lb**	840 ~~gal~~	
d		~~L~~		~~M~~mg	10^6 ~~gal~~	~~gal~~	min	

Finally, we need to convert **min** to **d**, using **1,440 min/d**. One of the things about the railroad track that makes it so powerful is that we don't have to think about whether we divide or multiply by 1,440 because **the units tell us what to do**. The only way this conversion factor can be entered into the railroad track is to put the **1,440 min** in the numerator so **min** cancel.

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d		~~L~~		~~M~~mg	10^6 ~~gal~~	~~gal~~	~~min~~	**d**

The only units remaining in the railroad track are **lb BOD/d** needed in the answer so the math is done. The arithmetic gives the answer:

265 x 0.625 x 8.34 x 840 x 1,440 ÷ 1,000,000 = **1,671 lb BOD/d**.

Many of you in California may have heard that water treatment plant certification has been moved from the California Department of Health Services to the Office of Operator Certification in the State Water Resources Control Board. We think our approach to doing math problems is so sound and can help so many operators, water and wastewater, WWTT is going to start doing math review classes for water treatment plant operators. If you know of anybody who is pursuing water treatment plant operator

certification, or if you are, visit WWTT's courses webpage here. The water classes aren't up as of this writing, but they will be soon!

Happy calculating. Let us know, by leaving a comment, if you want us to do a specific problem.