Problem of the Day

2014.Sept.27

Discussion

Many instances in wastewater math require the determination of the pounds or pounds per day of a constituent or chemical in a volume or flow. Operators should be very familiar with these calculations and understand how "they work." One such problem is the determination of how much better operators are operating their plants by changing their operational strategy.

Problem

Today's problem should make operators proud since it is based on "a true story."

Problem of the Day: The average effluent TSS concentration at the South River WWTP before process optimization was 18.6 mg/L. Process optimization significantly improved performance: the effluent TSS concentration now averages 12.4 mg/L. The flow rate to the plant averages 62 MGD. By how many tons per day has process optimization reduced the TSS discharged to the receiving water?

Solution

While the question asks to calculate "tons of TSS per day," it should be obvious that this is a pounds equation. Tons, like pounds, are a unit of weight. (I can hear the voice of my high school physics teacher, Mr. Bill Eakins, right now saying "mass and weight are not the same thing," which I get, but I'm not going to make a big deal out of it here.) As always, the railroad track is started out with the units desired in the answer between heavy vertical lines followed by an equals sign and the blank track..

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$$\left|\frac{\text{ton TSS}}{\text{d}}\right| = \frac{\qquad}{\qquad}$$

WWTT always starts the railroad track, when "calculating pounds," with concentration, which always should be in units of mg/L (if concentration is given in ppM—parts per million parts—this is the same as mg/L in our business). But the problem gives two concentrations: the effluent TSS concentration before and after process optimization. One could do two pounds calculations, before and after process optimization, and subtract one from the other. It is a simple matter, however, of taking the difference between the two concentrations given and then do one pounds calculation.

18.6 mg TSS/L − 12.4 mg TSS/L = 6.2 mg TSS/L

This is a good place to remind Problem-of-the-Day readers that **when adding or subtracting two or more numbers, they must be in the same units**. If you have 5 apples and 3 pears and you take away 2 pears, you have 5 apples and 1 pear. This may seem so obvious that it is silly to mention here. Maybe. But under the pressure of a certification exam, this bit of advise may be very, very helpful.

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$$\left|\frac{\text{ton }\mathbf{TSS}}{\text{d}}\right| = \frac{6.2\text{ mg }\mathbf{TSS}}{\text{L}}$$

Again, the reason that WWTT starts the railroad track out with the concentration is because it gets the units, in this case "TSS," needed in the answer in the railroad track (indicated in **bold**).

While their intent is to help operators, the State of California's Office of Operator Certification includes the following what WWTT will call a bastardization on the Equivalents and Formulae sheet included with every State certification exam (exactly written here as shown on the January 2014 revision):

$$\frac{8.34\text{ lbs}\cdot\text{L}}{\text{MG}\cdot\text{mg}}$$

OMG. What nonsense.

First of all, every operator should know that **no such conversion factor or physical constant exists**. Second, is it any wonder that so many operators are so confused by math and have so much anxiety over certification exams when those who should be "in the know" make such crazy stuff up? Third, don't the units in the denominator, "MG·mg," seem a bit confusing and, potentially, a source of error? Really, m-g-m-g?

In the 2014.Sept. 21 Problem of the Day, the following conversion factor was derived based on the fact that a liter (L) of water weighs 1,000,000 milligrams (M·mg):

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

WWTT uses this **real** conversion factor in the pounds equation to cancel mg/L.

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ton **TSS**	=	6.2 ~~mg~~ **TSS**	~~L~~	
d		~~L~~	M·~~mg~~	

The "M" now in the denominator is a reminder that the flow rate has to have the units Mgal in the numerator so the Ms cancel.

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ton **TSS**	=	6.2 ~~mg~~ **TSS**	~~L~~	62 ~~M~~gal	
d		~~L~~	~~M·mg~~	**d**	

Notice the units of flow rate, Mgal/d (**never MGD in the railroad track**) also puts days, "d," in the denominator, which are needed in the answer.

Next, gal is canceled by entering the density of water.

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ton **TSS**	=	6.2 ~~mg~~ **TSS**	~~L~~	62 ~~Mgal~~	8.34 lb	
d		~~L~~	~~M·mg~~	**d**	~~gal~~	

All that remains to finish the problem is the conversion of pounds to tons. There are 2,000 pounds in one ton, which is used to cancel lb.

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ton TSS	=	6.2 ~~mg~~ **TSS**	~~L~~	62 ~~Mgal~~	8.34 ~~lb~~	**ton**
d		~~L~~	~~M·mg~~	**d**	~~gal~~	2,000 ~~lb~~

With all units canceled except those required in the solution, the math is complete and the arithmetic gives the answer:

6.2 x 62 x 8.34 ÷ 2,000 = <u>1.6 ton TSS/d</u>.

Unbelievable: improving process performance by just 6.2 mg TSS/L means 1.6 tons fewer TSS per day going to the river!

As mentioned, this is a real life story; the success of the operators at this plant (not really called the South River WWTP) should make operators everywhere proud.

So, the question is: If 1.6 ton/d fewer TSS are going to the river, where are they going?

Obviously, the solids are staying in the plant. On the one hand, someone might argue that these solids mean more biosolids, after digestion, to haul away and more expense. And this is true. But on the other hand, these solids mean more solids to the anaerobic digesters, more methane production and more heat and power generated in cogeneration. The kinds of comparisons that operators of the Resource Recovery Utility of the Future are going to have to make is the question here: does the heat and power generated in the cogeneration system pay for—in terms of both dollars and carbon—the additional expense incurred hauling the extra biosolids and the carbon dioxide generated burning fossil fuels for that haul?

Wastewater operators everywhere should know their jobs are changing but it is a very good time to be in the business of water no matter where you live.