Problem of the Day

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The plant has two 100-ft diameter trickling filters. The media in each is 22 feet deep. The BOD concentration in the primary effluent averages 117 mg/L. The recirculation flow is set at a constant 100% of the influent flow, which averages 16 MGD. The BOD concentration in the secondary clarifier effluent is 10 mg/L, with a soluble BOD concentration of 3.5 mg/L. Calculate the organic loading to these trickling filters.

Introduction

This is very similar to yesterday's Problem of the Day. There are two very important things to remember when calculating the organic loading to trickling filters and many operator certification exams expect that operators know these:

1. The units on organic loading rate to trickling filters are always pounds of BOD per day per 1,000 cubic feet of media volume (lb BOD/d·1,000 ft^3).
2. Whatever is going on in the recirculation flow, it is ignored when calculating the organic loading; in other words, even though certification exam questions, like this one, will often give you the organic concentration (BOD, sBOD, COD, etc.) in the recirculation flow (i.e., the secondary effluent), it is **not** used in calculating the organic loading. Don't let them trick you into doing so!

There are basically two things you have to calculate to determine the organic loading to trickling filters: the lb BOD/d in the primary effluent flow going to the trickling filters and the volume of the media. The units that organic loading is expressed in (No. 1 above) tell you this. Both "steps" can be included in a single solution bridge.

Solution

The question does not ask the answer to be in any specific units, but all wastewater treatment plant operators should know that the units on the organic loading to trickling filters are always lb BOD/d·1,000 ft^3. Always. 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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lb BOD	=	
d·1,000 ft^3		

The units needed in the answer tell us that we are going to calculate the lb BOD/d going to the trickling filter and divide that by the volume of the media expressed as "1,000 ft^3." WWTT likes to start the solution bridge for pounds and pounds-per-day calculations with the concentration of the constituent of interest, in this case BOD, as shown in **bold**.

lb **BOD**	=	117 mg **BOD**	
d·1,000 ft^3		L	

Whenever mg/L are entered on the solution bridge, they are canceled.

lb **BOD**	=	117 ~~mg~~ **BOD**	~~L~~	
d·1,000 ft^3		~~L~~	M·~~mg~~	

The M in this conversion factor reminds us we need an Mgal to cancel the Ms. This also puts d in the denominator of the solution bridge as needed in the answer.

lb **BOD**	=	117 ~~mg~~ **BOD**	~~L~~	16 Mgal	
d·1,000 ft^3		~~L~~	M·~~mg~~	**d**	

Entering the density of water so gal cancel in the numerator and denominator also puts lb in the numerator of the solution bridge as needed in the answer.

lb BOD	=	117 ~~mg~~ **BOD**	~~L~~	16 Mgal	8.34 **lb**
d·1,000 ft^3		~~L~~	M·~~mg~~	**d**	gal

I hope you recognize that what we've done to this point is simply a pounds-per-day calculation. We now have to divide by the volume of the media in the two trickling filters. The shape of a trickling filter is that of a coffee can. To calculate the volume of a coffee can, we multiply the area of the circle (0.785 x diameter^2) by the depth. This calculation is entered, per trickling filter (TF), in the denominator of the solution bridge because we have to divide by volume.

lb BOD	=	117 ~~mg~~ **BOD**	~~L~~	16 ~~Mgal~~	8.34 **lb**	TF		
d·1,000 ft^3		~~L~~	~~M·mg~~	**d**	~~gal~~	0.785	100^2 ft^2	22 ft

But how many trickling filters are there? Let the units tell you were to enter "2 TF" so the units cancel.

lb BOD	=	117 ~~mg~~ **BOD**	~~L~~	16 ~~Mgal~~	8.34 **lb**	~~TF~~			
d·1,000 ft^3		~~L~~	~~M·mg~~	**d**	~~gal~~	0.785	100^2 ft^2	22 ft	2 ~~TF~~

Like yesterday, even though we have ft^3 in the denominator of the solution bridge as needed in the answer, the unit we really need is 1,000 ft^3. Under the pressure of an exam, I guarantee you that you will stumble here with the question, "Do I divide by 1,000, or multiply?" Here is WWTT's trick so you will not even have to think about it. First, multiplying the solution bridge by 1,000 ft^3/1,000 ft^3 is just multiplying by 1, so it doesn't change the arithmetic at all.

lb BOD	=	117 ~~mg~~ **BOD**	~~L~~	16 ~~Mgal~~	8.34 **lb**	~~TF~~				1,000 ft^3
d·1,000 ft^3		~~L~~	~~M·mg~~	**d**	~~gal~~	0.785	100^2 ft^2	22 ft	2 ~~TF~~	1,000 ft^3

Second, the 1,000 ft^3 in the denominator is bracketed, [ ], so that it is kept together as a standalone unit, the unit we need in the answer. The brackets also mean that when you get to the 1,000 in the brackets, it is **not** entered into your calculator when doing the arithmetic, but the 1,000 in the numerator, which is not in brackets, is. Note the cancelation of ft^3 in the denominator and numerator.

lb BOD	=	117 ~~mg~~ **BOD**	~~L~~	16 ~~Mgal~~	8.34 **lb**	~~TF~~				1,000 ~~ft^3~~
d·1,000 ft^3		~~L~~	~~M·mg~~	**d**	~~gal~~	0.785	100^2 ~~ft^2~~	22 ~~ft~~	2 ~~TF~~	[**1,000 ft^3**]

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.

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lb BOD	=	117 ~~mg~~ **BOD**	~~L~~	16 ~~Mgal~~	8.34 **lb**	~~TF~~				1,000 ~~ft^3~~
d·1,000 ft^3		~~L~~	~~M·mg~~	**d**	~~gal~~	0.785	100^2 ~~ft^2~~	22 ~~ft~~	2 ~~TF~~	[**1,000 ft^3**]

$117 \times 16 \times 8.34 \times 1{,}000 \div 0.785 \div 100 \div 100 \div 22 \div 2 =$ **45.2 lb BOD/d•1,000 ft^3**.

Discussion

Notice when doing the arithmetic, as discussed, that the 1,000 in the numerator is entered in your calculator but the 1,000 in brackets in the denominator is not. This little trick is real helpful under the pressure of an exam.

This is a very important calculation to master for certification exams. Invariably, you will have to calculate the organic loading to trickling filters somewhere in the progression of exams you will take as you better your credentials with higher and higher levels of certification. Wastewater treatment plant operation is a noble and much needed profession. As I believe that a wastewater treatment operator protects more lives in a day than a doctor will save in his or her lifetime, it is a profession as worthy as the medical profession.

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.