Problem of the Day

2015.Dec.06

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In doing a process control check, the chief plant operator of the plant in the last three days' Problems of the Day realized the primary effluent BOD concentration was high. The average reported two days ago was 182 mg/L. She recalled that Operations had taken two primary clarifiers off line a month ago for maintenance and hadn't yet returned them to service. She put them back on-line and the primary effluent BOD concentration yesterday was 134 mg/L. She noticed a significant decrease in the primary effluent TSS concentration as well. If the flow to the plant yesterday was 42.3 MGD (a little higher than it has been), how many pounds of BOD were treated by the activated sludge system yesterday.

Introduction

Operator training materials don't explain primary clarifiers very well. I'm not going to go into a huge treatise here, but suffice it to say, very simply, that primary clarifiers can only remove settleable TSS and the BOD that is associated with those solids. And, not all TSS coming down the pipe to our treatment plants are settleable, some or non settleable. Not only is there BOD associated with the settleable TSS, there is BOD associated with the non settleable TSS as well. Some of the BOD coming down the pipe to our treatment plants is dissolved. That BOD is the same "material," for all intents and purposes, with volatile (because, by definition of BOD, it is organic) dissolved solids (VDS). Herein lies the crux of the matter: Primary clarifier performance has much more to do with the characteristics of the wastewater than it does with how the primary clarifiers are either designed or operated. Primary clarifiers cannot remove non settleable TSS and the BOD associated with them nor can they remove dissolved solids, so they can't remove soluble BOD either. We forget, and our trainers and training materials don't tell us, that TSS and BOD are intertwined with each other; we think of them as distinctly different. While the analytical procedures for measuring TSS, VSS, TDS, VDS, and BOD, for example, are very different, they measure a lot of the same "stuff."

The CPO in today's Problem of the Day has put two additional primary clarifiers on line and observed a significant improvement in BOD and TSS removal. Why would that be?

By adding more primary clarifiers, the CPO has decreased the surface overflow rate (SOR) in the primary clarifiers. Another thing our trainers and training materials don't tell us or if they do, they aren't very clear about it, is that the SOR is a measure of the velocity of the flow exiting a clarifier (either primary, secondary or tertiary). The settleable TSS, in order to be removed, have to have a settling velocity, basically (not quite, but close enough), that is greater than the SOR. Those solids with settling velocities less than the SOR will end up in the effluent. So, by adding two additional primary clarifiers, the CPO lowered the SOR so more settleable TSS, and the BOD associated with those solids, are removed.

Solution

This is a very straightforward pounds-per-day calculation. The information given given in the problem and assumed is listed:

1. Primary effluent flow = 42.3 Mgal/d (neglecting the primary sludge flow)
2. Primary effluent BOD concentration = 134 mg BOD/L
3. Density of primary effluent = 8.34 lb/gal (assumed since not given)

Today's problem asks to calculate the BOD loading, lb BOD/d, going to the activated sludge facility. 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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$$\left|\frac{\text{lb BOD}}{\text{d}}\right| = \underline{\qquad\qquad\qquad\qquad}$$

As I already said, this is simply a pounds-per-day calculation. Different people like to start the solution bridge for these problems differently. I almost always start with concentration so I can get whatever constituent units (in this case, BOD, No. 2 in the list) that I need in the answer on the solution bridge as shown in bold.

lb **BOD**	=	134 mg **BOD**	
d		L	

Although it kind of goes agains my new rule to get all the units on the solution bridge needed in the answer before canceling unwanted units, I always like to "get rid of" mg and L as soon as I enter them on the solution bridge. This is done with the conversion factor M·mg/L, which has to be entered upside down to cancel the unwanted units.

lb **BOD**	=	134 ~~mg~~ **BOD**	~~L~~	
d		~~L~~	M·~~mg~~	

The flow (No. 1) is now entered to get the units d in the denominator as shown in bold. Note, too, that the Ms cancel.

lb **BOD**	=	134 ~~mg~~ **BOD**	~~L~~	42.3 ~~M~~gal	
d		~~L~~	~~M·mg~~	**d**	

The last units needed in the answer are lb which are entered on the solution bridge using the density of water (in this case primary effluent), No. 3. One option is to cancel the M by entering the volume, in Mgal, of each aeration basin in the denominator of the solution bridge. Remember, whenever the word "per" comes across you lips ("2.2 Mgal **per** AB") you jump across the bridge.

lb BOD	=	134 ~~mg~~ **BOD**	~~L~~	42.3 ~~Mgal~~	8.34 **lb**
d		~~L~~	~~M·mg~~	**d**	~~gal~~

Not only are all the units needed in the answer now on the solution bridge, all the unwanted units have canceled leaving only those needed in the answer, **lb BOD/d**. This tells us the solution bridge is complete. The arithmetic, then, gives us the answer.

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lb BOD	=	134 ~~mg~~ **BOD**	~~L~~	42.3 ~~Mgal~~	8.34 **lb**
d		~~L~~	~~M·mg~~	**d**	~~gal~~

134 × 42.3 × 8.34 = **47,273 lb BOD/d**.

Discussion

It would be just like a certification exam question where two primary effluent BOD concentrations are given. The people that make exam questions up love to come up with little tricks to see if they can stump you. Don't let them. Read every question carefully and **understand** each piece of information given. True understanding is the key to knowing whether a particular piece of information given in the problem

statement is going to be used in the solution or not. I get this question all the time: How do I know when I'm not going to use some of the information given?

Honestly, I can't answer this. I can only say what I just said: Read every question carefully and **understand** each piece of information given.

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.