Problem of the Day

2015.Jun.20

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The flow to the plant is 4.5 MGD. The total on-line aeration basin volume is 2.2 million gallons. It is late winter and the MLSS is higher than the operator wants at 4,750 mg/L. Sludge settleability has recently deteriorated, the SVI is 170 mL/g. The sludge blankets in the two 16-ft deep secondary clarifiers is averaging 7.5 feet. Core sampling in the clarifiers indicates an average solids concentration of 3,900 mg/L. Each secondary clarifier has a volume of 0.5 million gallons. Find: (a) the total mass of solids in the secondary clarifiers, and (b) assuming this entire mass of solids was transferred to the aeration basins, by how many mg/L would the MLSS concentration increase.

Introduction

This problem is actually based, somewhat, on a plant visit I made a couple of weeks ago. As a result of various constraints—the most severe being the operator's boss who insisted the biosolids disposal costs were "through the roof" and needed to be held in check—the operator wasn't wasting as much as he thought was needed.

I see this all too often: way too many solids in the activated sludge system leading to rising blankets and poor sludge quality until a storm event finally comes along causing a permit-busting loss of solids in the effluent. This scenario does not happen over night. In the case upon which I am basing today's problem, the operator likes to run the MLSS concentration in the winter at 4,000-4,500 mg/L "in order to make his effluent nitrogen numbers." Although he calculated it every day, he didn't pay it any attention: these MLSS concentrations resulted in an SRT of greater than 30 days. Operators need to understand that operating at longer and longer SRTs does **not** make nitrification work better. **An SRT of 30 days is excessive**. Then when he wanted to get rid of the extra solids he knew he was carrying as the wastewater was warming up, he was told he was busting the budget. As the SVI deteriorated in the activated sludge system, so too did the float TSS concentration in the thickened WAS causing a decrease in the thickening and dewatering processes requiring more hauling (no solids treatment at his plant). In a nutshell: the problems associated with a constipated activated sludge system snowballs through the entire plant. Although it is solids (that is, biomass) that puts "treatment" in wastewater treatment, too many solids is a very bad operational strategy no matter what season.

Solution—Part a

The first part of the question asks to calculate the mass of solids in the secondary clarifiers. This is just a pounds calculation (not a pounds-per-day calculation since we are dealing with a volume and not a flow rate). The solids in activated sludge secondary clarifiers are mixed liquor solids, so we are calculating lb MLSS. These units are entered between heavy vertical lines, as always, followed by an equals sign and the blank solution bridge.

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$$\left| \text{lb MLSS} \right| = \underline{\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad}$$

The following list summarizes the information given in the problem statement expressed in the appropriate units:

1. Plant flow = 4.5 Mgal/d
2. Aeration basin volume, total = 2.2 Mgal
3. MLSS concentration in aeration basins = 4,750 mg MLSS/L
4. SVI = 170 mL/g
5. Number of secondary clarifiers (SC) = 2 SC
6. MLSS concentration in secondary clarifiers = 3,900 mg MLSS/L
7. Secondary clarifier volume, each = 0.5 Mgal
8. Secondary clarifier depth = 16 ft
9. Average sludge blanket depth = 7.5 ft

WWTT prefers to start the solution bridge for pounds and pounds-per-day calculations with the concentration of whatever we're calculating pounds of; in this case, MLSS in the secondary clarifiers, not the aeration basins, so make sure you use the correct MLSS concentration. This unit, MLSS, is needed in the answer so is shown in bold on both sides of the equals sign.

$$\text{lb } \mathbf{MLSS} = \frac{3{,}900 \text{ mg } \mathbf{MLSS}}{\text{L}}$$

Whenever the units mg/L are entered on the solution bridge, WWTT cancels them.

$$\text{lb } \mathbf{MLSS} = \frac{3{,}900 \cancel{\text{mg}} \mathbf{MLSS}}{\cancel{\text{L}}} \cdot \frac{\cancel{\text{L}}}{\text{M}\cdot\cancel{\text{mg}}}$$

The M in M·mg in the denominator reminds us we need an Mgal in the numerator to cancel the Ms. Be careful here as we're given three pieces of information that have Mgal in the units (Nos. 1, 2 and 7). Which one do we use? Since we're calculating the lb MLSS in the secondary clarifiers, obviously we enter No. 7 into the solution bridge. And remember, the volume given is **per** secondary clarifier (SC).

$$\text{lb } \mathbf{MLSS} = \frac{3{,}900 \cancel{\text{mg}} \mathbf{MLSS}}{\cancel{\text{L}}} \cdot \frac{\cancel{\text{L}}}{\cancel{\text{M}\cdot\text{mg}}} \cdot \frac{0.5 \cancel{\text{M}}\text{gal}}{\text{SC}}$$

There are two secondary clarifiers. We enter this so the SC units cancel, denominator and numerator.

$$\text{lb } \mathbf{MLSS} = \frac{3{,}900 \cancel{\text{mg}} \mathbf{MLSS}}{\cancel{\text{L}}} \cdot \frac{\cancel{\text{L}}}{\cancel{\text{M}\cdot\text{mg}}} \cdot \frac{0.5 \cancel{\text{M}}\text{gal}}{\cancel{\text{SC}}} \cdot \frac{2 \cancel{\text{SC}}}{}$$

There are gal to cancel in the numerator and lb are needed in the numerator of the answer. We accomplish both by entering the density of water. Since all the units have canceled except those needed in the answer, we know the solution bridge is complete. The arithmetic gives the answer to Part a.

$$\mathbf{lb\ MLSS} = \frac{3{,}900 \cancel{\text{mg}} \mathbf{MLSS}}{\cancel{\text{L}}} \cdot \frac{\cancel{\text{L}}}{\cancel{\text{M}\cdot\text{mg}}} \cdot \frac{0.5 \cancel{\text{Mgal}}}{\cancel{\text{SC}}} \cdot \frac{2 \cancel{\text{SC}}}{} \cdot \frac{8.34 \mathbf{lb}}{\cancel{\text{gal}}}$$

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3,900 x 0.5 x 2 x 8.34 = **<u>32,526 lb MLSS</u>**.

Solution—Part b

The second part of the question asks to calculate the increase in the MLSS concentration in the aeration basins if the mass of solids in the secondary clarifiers just calculated was transferred from the secondary clarifiers to the aeration basins. This is a reverse pounds calculation: we are given pounds (calculated in Part a) and volume (aeration basin volume) and we have to calculate concentration, mg MLSS/L. These units are entered between heavy vertical lines, as always, followed by an equals sign and the blank solution bridge.

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$$\left|\frac{\text{mg MLSS}}{\text{L}}\right| = \frac{\quad}{\quad}$$

Remember the rule: Whenever a question asks to solve for mg/L, the solution bridge will **always** begin with M·mg/L. It's that simple. Doing so puts the units mg and L needed in the answer on the solution bridge, as shown in bold.

$$\left|\frac{\textbf{mg}\ \text{MLSS}}{\textbf{L}}\right| = \left|\frac{\text{M}\cdot\textbf{mg}}{\textbf{L}}\right| \frac{\quad}{\quad}$$

Although there are options for what to enter next, WWTT likes to enter mg/L of what; in this case, MLSS. In the list there are two pieces of information given that have the units MLSS (Nos. 3 and 6), but both of these are mg MLSS/L. No, we want lb MLSS and we get that from Part a. The MLSS unit is shown in bold on both sides of the equals sign.

$$\left|\frac{\textbf{mg MLSS}}{\textbf{L}}\right| = \left|\frac{\text{M}\cdot\textbf{mg}}{\textbf{L}}\right| \frac{32{,}526\ \text{lb}\ \textbf{MLSS}}{\quad}$$

All the units needed in the answer are now on the solution bridge along with other unwanted units that need to be canceled in the usual way, numerator and denominator. The M in the numerator is canceled by entering Mgal in the denominator. Again, however, there are three pieces of information given that have Mgal in the units (Nos. 1, 2 and 7). Since we are calculating concentration in the aeration basins, we enter No. 2 to cancel the Ms. Remember, the aeration basin volume given in No. 2 is the total volume and it is **not** per aeration basin.

$$\left|\frac{\textbf{mg MLSS}}{\textbf{L}}\right| = \left|\frac{\cancel{\text{M}}\cdot\textbf{mg}}{\textbf{L}}\right| \frac{32{,}526\ \text{lb}\ \textbf{MLSS}}{2.2\ \cancel{\text{M}}\text{gal}}$$

The density of water is entered to cancel the remaining unwanted units. 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.

$$\frac{\textbf{mg MLSS}}{\textbf{L}} = \frac{\cancel{\textbf{M}}\textbf{mg}}{\textbf{L}} \cdot \frac{32{,}526\ \cancel{\text{lb}}\ \textbf{MLSS}}{2.2\ \cancel{\text{Mgal}}} \cdot \frac{\cancel{\text{gal}}}{8.34\ \cancel{\text{lb}}}$$

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$$\frac{\textbf{mg MLSS}}{\textbf{L}} = \frac{\cancel{\textbf{M}}\textbf{mg}}{\textbf{L}} \cdot \frac{32{,}526\ \cancel{\text{lb}}\ \textbf{MLSS}}{2.2\ \cancel{\text{Mgal}}} \cdot \frac{\cancel{\text{gal}}}{8.34\ \cancel{\text{lb}}}$$

32,526 ÷ 2.2 ÷ 8.34 = **1,773 mg MVSS/L**.

Discussion

Wow! If all the solids in the secondary clarifiers were transferred over to the aeration basins, the MLSS concentration would increase by nearly 1,800 mg/L to about 6,550 mg MLSS/L. Now do you see that is **way** too many solids?

Besides the lesson here of keeping the solids concentrations down, **by controlling the SRT**, there is another lesson: **Don't let sludge blankets build up in secondary clarifiers**! I can't emphasize this enough. By the way, just for the record you should know that it is not possible to have no sludge blankets in secondary clarifiers because there will always be some sludge blanket. But that's a discussion for another day.

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.