Problem of the Day

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The BOD removal efficiency through primary clarification averages 34%. The operators performed a test of chemically enhanced primary treatment (CEPT) on one primary clarifier using ferric chloride and anionic polymer. At the smallest doses tested, the operators found the BOD removal efficiency increased to 39%. The operators also showed this increase was statistically different. How many more pounds of BOD per day would be removed if they applied CEPT full scale? The average flow to the plant is 5.8 MGD and the influent BOD averages 325 mg/L.

Introduction

While this problem is simply a “pounds” calculation, it highlights a very important subject: chemically enhanced primary treatment (CEPT). While the cost of the chemicals used in CEPT must be accounted for, getting more BOD out in the primary clarifiers means more gas production in anaerobic digesters and, if the gas is used for power generation, more power. Also, it costs wastewater treatment plants a lot of money in aeration to get rid of BOD in activated sludge systems, so the more BOD removed in the primary clarifiers, the less aeration energy is needed.

With all that said, the wastewater treatment profession is faced with a dilemma. As nutrient removal is being required of more and more plants, we’re faced with the question: Is the BOD coming down the pipe at us best used for making power or for driving nutrient removal? As effluent nutrient requirements get more strict, this is a question more agencies are asking. And it’s not easily answered.

One thing is for sure, though, and that is activated sludge will never be “starved” by increasing the BOD removal efficiency in the primary clarifiers. Operators get this wrong all the time because that’s what they’ve been taught over and over and over again. First of all, because about a third of the BOD in municipal wastewater is soluble, there is no way that primary clarifiers are ever going to remove all the BOD. And second, fewer BOD pounds to the aeration basin just means that the amount of biomass will be less in the activated sludge system. “Less” is different than “starved.” Where operators get in trouble is when they try to maintain a certain concentration or mass of either MLSS or MLVSS in the activated sludge system. If the fewer BOD pounds is not enough to support the amount of biomass the operator thinks should be in the system and is targeting, the activated sludge process will destabilize. This is one of the main reasons that controlling the activated sludge process by maintaining a target concentration or mass of either MLSS or MLVSS is **not**—I repeat, **not**—a viable control strategy. Many operators need to change their paradigm on this.

Solution

The question specifically asks to calculate “How many more pounds of BOD per day . . .” These units, lb BOD/d, are entered between heavy vertical lines, as always, followed by an equals sign and the blank solution bridge.

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

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

1. Influent BOD concentration = 325 mg BOD/L
2. Influent flow = 5.8 Mgal/d
3. Difference in BOD removal efficiencies = (39 − 34)% = 5% = 0.05

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, BOD. This unit is needed in the answer so is shown in bold on both sides of the equals sign.

$$\left|\frac{\text{lb } \mathbf{BOD}}{\text{d}}\right| = \left|\frac{\text{325 mg } \mathbf{BOD}}{\text{L}}\right| \text{\_\_\_\_\_}$$

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

$$\frac{\text{lb } \mathbf{BOD}}{\text{d}} = \frac{325\ \cancel{\text{mg}}\ \mathbf{BOD}}{\cancel{\text{L}}} \cdot \frac{\cancel{\text{L}}}{\text{M}\cdot\cancel{\text{mg}}} \cdot \frac{\quad}{\quad}$$

We could calculate the pounds of BOD removed per day with and without CEPT and find the difference to come up with the answer. Instead, the difference in removal efficiencies is 5%, meaning CEPT removes 5% more of the influent BOD. This 5% is entered on to the solution bridge, as a decimal, to calculate how many more pounds of BOD per day are being removed with CEPT. When a percent is expressed as a decimal, it has no units associated with it.

$$\frac{\text{lb } \mathbf{BOD}}{\text{d}} = \frac{325\ \cancel{\text{mg}}\ \mathbf{BOD}}{\cancel{\text{L}}} \cdot \frac{\cancel{\text{L}}}{\text{M}\cdot\cancel{\text{mg}}} \cdot 0.05 \cdot \frac{\quad}{\quad}$$

The M in M·mg in the denominator reminds us we need an Mgal in the numerator to cancel the Ms.

$$\frac{\text{lb } \mathbf{BOD}}{\text{d}} = \frac{325\ \cancel{\text{mg}}\ \mathbf{BOD}}{\cancel{\text{L}}} \cdot \frac{\cancel{\text{L}}}{\cancel{\text{M}}\cdot\text{mg}} \cdot 0.05 \cdot \frac{5.8\ \cancel{\text{M}}\text{gal}}{\text{d}} \cdot \frac{\quad}{\quad}$$

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.

$$\frac{\mathbf{lb\ BOD}}{\mathbf{d}} = \frac{325\ \cancel{\text{mg}}\ \mathbf{BOD}}{\cancel{\text{L}}} \cdot \frac{\cancel{\text{L}}}{\cancel{\text{M}}\cdot\text{mg}} \cdot 0.05 \cdot \frac{5.8\ \cancel{\text{Mgal}}}{\mathbf{d}} \cdot \frac{8.34\ \mathbf{lb}}{\cancel{\text{gal}}}$$

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325 x 0.05 x 5.8 x 8.34 = **786 lb BOD/d**.

Discussion

That amount of BOD doesn't seem like much, but it's a lot of air that you wouldn't need in the aeration basin. Every dollar an operator saves in his or her operation is a dollar our ratepayers don't have to pay. That's a good thing.

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.