Problem of the Day

2015.Jul.27

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A plant removes 22,500 pounds of TSS in the primary clarifiers per day. If the primary sludge is pumped at 2.5% total solids, how many gallons of sludge per day flow to the anaerobic digesters?

Introduction

There is a big difference when concentration is expressed as a percent versus when it is expressed in units of mg/L. Percent is parts per hundred parts (ppH); mg/L is parts per million parts (ppM). The magnitude of the difference between the two is easy to appreciate from answering this question:

What would you rather I give you: $100 or $1,000,000?

Big difference!

If concentration is given in mg/L or ppM, you will most certainly be using the pounds or pounds-per-day equation, which you have to be able to do with hardly a thought. When concentration is given in percent, WWTT uses a slightly different problem solving tactic which hinges on the use of units to tell us what to do.

This problem is the same as the last two Problems of the Day except that the sludge is being pumped at 2.5% TS instead of 6.5% TS (yesterday) and 4.5% (the day before yesterday). Comparison of the three answers will speak to the importance of sludge thickening. It is hugely important.

Solution

The list of "givens" expressed in the units used by WWTT:

1. Solids removed = 22,500 lb TSS/d
2. Primary sludge ("sldg") TS concentration = 2.5% TS = 2.5 lb TS/100 lb sldg
3. Primary sludge density = 8.34 lb sldg/gal sldg

Although the primary sludge density has to be assumed equal to water in order to do this problem, notice how it is labeled in this list. This is very important. Primary sludge is some pretty nasty stuff so we don't ever want to mistake it for water. Plus, the way we have it labeled in the list helps us to work the solution bridge.

The question specifically asks to find "gallons of sludge per day" so the units gal sldg/d are put between heavy vertical lines, as always, followed by an equals sign and the blank solution bridge.

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$$\left|\frac{\text{gal sldg}}{\text{d}}\right| = \frac{\qquad\qquad}{\qquad\qquad}$$

If you label the information as we've done in the list above, it is very easy to begin the solution bridge: the units gal sldg, needed in the numerator of the answer, only appear in one place (No. 3) so the density of the sludge is entered "upside down."

$$\left|\frac{\textbf{gal sldg}}{\text{d}}\right| = \left|\frac{\textbf{gal sldg}}{8.34 \text{ lb sldg}}\right| \frac{\qquad\qquad}{\qquad\qquad}$$

The unit lb sldg in the denominator is canceled by entering the concentration of TS in the sludge (No. 2).

$$\left|\frac{\textbf{gal sldg}}{\text{d}}\right| = \left|\frac{\textbf{gal sldg}}{8.34 \text{ ~~lb sldg~~}}\right| \left|\frac{100 \text{ ~~lb sldg~~}}{2.5 \text{ lb TS}}\right| \frac{\qquad\qquad}{\qquad\qquad}$$

It is general practice when doing sludge problems like this that total solids (TS) and total suspended solids (TSS) be treated as the same. In fact, they have to be treated as the same in order to do the problem. Keep in mind, though, that TS does not equal TSS. TS are the sum of TSS and TDS (total dissolved solids):

TS = TSS + TDS

To kind of keep this straight in my mind —the fact that we are assuming TS = TSS—I put the second S in TSS in parentheses, TS(S); lb TS now cancel with lb TS(S).

gal sldg	=	**gal sldg**	100 ~~lb sldg~~	22,500 ~~lb TS(S)~~
d		8.34 ~~lb sldg~~	2.5 ~~lb TS~~	**d**

Since all the unwanted units have now canceled and only the units needed in the answer remain (gal sldg/d), we know the solution bridge is complete. The arithmetic gives the answer.

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gal sldg	=	**gal sldg**	100 ~~lb sldg~~	22,500 ~~lb TS(S)~~
d		8.34 ~~lb sldg~~	2.5 ~~lb TS~~	**d**

100 x 22,500 ÷ 8.34 ÷ 2.5 = **107,914 gal sldg/d**.

Discussion

This is a very typical sludge problem. Readers of Problem of the Day should practice the labeling convention used here. Once mastered, these kind of problems are very easily solved.

The following summarizes the last three Problems of the Day. In all three problems, the same number of pounds of solids are pumped each day but the concentration of solids in the sludge was varied.

Primary sludge @ 2.5% TS: 108,000 gal sldg/d (48,000 gal/d more water than 4.5% TS)
Primary sludge @ 4.5% TS: 60,000 gal sldg/d (18,500 gal/d more water than 6.5% TS)
Primary sludge @ 6.5% TS: 41,500 gal sldg/d (66,500 gal/d **less** water than 2.5% TS)

As you can see, just small differences in the percent total solids in the sludge have a huge impact on the amount of water going to the digesters. The cost and performance impacts of this are staggering.

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.