



**WASTEWATER TECHNOLOGY  
T R A I N E R S**

*Transforming today's operators into tomorrow's water quality professionals*

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**Problem of the Day  
2015.May.27**

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Twenty-five thousand gallons per day (25,000 gal/day) of raw sludge is pumped to an anaerobic digester. Lab tests show this sludge to contain 4.6% TS and 75% VS. The specific gravity of the raw sludge is 1.015. How many pounds per day of volatile solids are pumped to the anaerobic digester?

## Introduction

Generally speaking, assuming the density of raw sludge is equal to water, 8.34 lb sldg/gal sldg, is valid up to a TS concentration of around 6-7%. The specific gravity given in today's problem is nearly equal to 1.0, the specific gravity of water, which reflects the TS concentration given, 4.6%. We are considering a density other than water in today's problem to test my assertion that the conversion factor 1% = 10,000 mg/L can only be used when the density of the liquid is equal to water.

## Solution

As with most problems, the solution bridge starts with identifying the units needed in the answer. Specifically, the problem states, "[h]ow many pounds per day of volatile solids," so that's how we start things off: The units needed in the answer, lb VS/d, are entered between heavy vertical lines followed by an equals sign and the blank solution bridge.

**Problem of the Day:** Twenty-five thousand gallons per day (25,000 gal/day) of raw sludge is pumped to an anaerobic digester. Lab tests show this sludge to contain 4.6% TS and 75% VS. The specific gravity of the raw sludge is 1.015. How many pounds per day of volatile solids are pumped to the anaerobic digester?

lb VS	=				
d					

Again, the information from the problem statement is repeated here and expressed, with units, the way WWTT teaches:

1. 25,000 gal/d = 25,000 gal sldg/day (sludge is abbreviated sldg)
2. 4.6% TS = 4.6 lb TS/100 lb sldg
3. 75% VS = 75 lb VS/100 lb TS

Notice from this list the units gal sldg and lb sldg. Density is used in many, many wastewater math problems to convert between gal and lb and vice versa. Different from yesterday's problem, the specific gravity of the raw sludge is given, 1.015, so it is multiplied by the density of water to calculate the density of the sludge and, as before, **labeled very specifically**:

4. 1.015 x 8.34 lb/gal = 8.465 lb sldg/gal sldg

In most instances, the solution bridge is started on the righthand side of the equals sign with the units needed in the numerator of the answer, in this case lb VS. In the list given, the only place the units lb VS appear is in No. 3 so this starts the solution bridge:

<b>lb VS</b>	=	<b>75 lb VS</b>			
d		100 lb TS			

The units lb VS need to be preserved because they are needed in the answer. This is why they are shown in bold on both sides of the equals sign. From this point, the solution is found by canceling out unwanted units. In order to cancel units, they need to be in the numerator and the denominator. The units lb TS need to be canceled. In the list given, the only other place the units lb TS appear is in No. 2. This factor, then, is entered into the solution bridge so the units lb TS cancel in the numerator and denominator as shown.

<b>lb VS</b>	=	<b>75 lb VS</b>	<del>4.6 lb TS</del>		
d		<del>100 lb TS</del>	100 lb sldg		

Now the units lb sldg need to be cancel. The only other place these units show up in the list is No. 4. This factor, then, is entered into the solution bridge so the units lb sldg cancel in the numerator and denominator as shown.

lb VS	=	75 lb VS	4.6 lb-TS	8.465 lb-sldg	
d		100 lb-TS	100 lb-sldg	gal sldg	

Now the units gal sldg need to be canceled. The only other place these units show up in the list is No. 1. This factor, then, is entered into the solution bridge so the units gal sldg cancel in the numerator and denominator as shown. Notice this factor has the units d needed in the denominator of the answer.

lb VS	=	75 lb VS	4.6 lb-TS	8.465 lb-sldg	25,000 gal-sldg
d		100 lb-TS	100 lb-sldg	gal-sldg	d

Since the only units remaining are the units needed in the answer, lb VS/d, we know the solution bridge is complete. The arithmetic gives the answer:

$$75 \times 4.6 \times 8.465 \times 25,000 \div 100 \div 100 = \underline{\underline{7,301 \text{ lb VS/d}}}$$

### Discussion

Many operators would have tackled this problem by converting 4.6% TS to 46,000 mg TS/L given the equivalent given yesterday, 1% = 10,000 mg/L. They would have then reasoned that 75% of the TS was VS so would multiply the TS concentration by 0.75 to get the VS concentration:

$$0.75 \times 46,000 = 34,500 \text{ mg VS/L}$$

Using this concentration, the raw sludge flow converted to Mgal/d (25,000 gal/d = 0.025 Mgal/d), and the density of the raw sludge calculated above in the pounds-per-day calculation gives this solution bridge:

lb VS	=	34,500 mg VS	L	0.025 Mgal	8.465 lb
d		L	Mmg	d	gal

Since all the units have canceled except those needed in the answer, lb VS/d, the solution bridge is complete. The arithmetic gives the answer:

$$34,500 \times 0.025 \times 8.465 = \underline{\underline{7,301 \text{ lb VS/d}}}$$

This is the same answer calculated above. Based on this result, I have to eat a little crow and admit I was wrong yesterday and say that converting from percent to mg/L using the conversion factor 1% = 10,000 mg/L works with one very important caveat: **the density of the solution, if different than water, has to be used in the pounds and pounds-per-day calculations** (an example of doing it wrong is given tomorrow). If you remember to use the appropriate density, you will get the correct answer. Again, I was wrong.

Okay, but I still don't like using 1% = 10,000 mg/L. Here's why:

1. You have to remember to use the appropriate density if it's not equal to 8.34 lb/gal
2. You have to make the conversion from % to mg/L and there is the **very real likelihood** you will misplace the decimal point
3. If volume or flow is given in other units, you have to convert it to Mgal or Mgal/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.**