Problem of the Day

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The influent flow to the facility is 4.8 MGD. The influent BOD, TSS and VSS concentrations are 335, 355, and 263 mg/L, respectively. The primary clarifiers remove 44.5% of the BOD and 67.8% of the TSS. The digested sludge has a VS concentration of 52.1%. Calculate the volatile solids reduction in the digesters.

Introduction

The volatile solids reduction (VSR, some say "removal" instead of "reduction") is a very important calculation for both anaerobic and aerobic digesters. For example, the "503 Regs," which regulate biosolids disposal, require a VSR in the plant's digesters of at least 38% for land application of biosolids, whether they are Class A or Class B. I worked with one operator who ran such a high SRT in his oxidation ditch (greater than 60 days!) that he was unable to meet the requirement of 38% VSR through his aerobic digester: The volatile solids in the WAS was very low because of the high SRT (the solids were being aerobically digested in the oxidation ditch). Note, too, that for any certification exam problem that has anything to do with anaerobic digester gas, the VSR has to be calculated first even though the question doesn't ask for it.

The VSR calculation is simple enough when looking at the equation:

$$\text{VSR, \%} = \frac{(.VS_{in} - .VS_{out}) \times 100}{.VS_{in} - (.VS_{in} \times .VS_{out})}$$

where $.VS_{in}$ is the **decimal** percent of the sludge influent to the digester and $.VS_{out}$ is the **decimal** percent of the digested sludge, which, to be politically correct, should be called biosolids since it is post digestion. VSR is always reported as a percent.

At least in California, the calculators allowed into certification exams don't like this equation very much. As a result, examinees tend to do the calculation in the numerator and write down the number, then do the calculation in the denominator and write down the number, and then divide the numerator by the denominator. This is an okay strategy, but not one that WWTT recommends. The reason: Every time you write a number down from the display of your calculator and every time you punch in a number from the page into your calculator, you risk transposing numbers, especially under the pressure of a certification exam. Be careful. WWTT always emphasizes the following when calculating VSR:

1. The volatile solids percentages must be expressed as decimals
2. Do not round any numbers as you work through this calculation until the end; the calculation is sensitive to rounding
3. Practice, practice, practice doing the VSR calculation with the calculator you will be taking to the exam before the exam (practice means getting the correct answer every time)

Solution

The VSR calculation doesn't work very well using the solution bridge; it's one of those calculations operators do that they just have to plug the numbers into the equation and turn the crank.

But wait a second, the problem didn't give us the %VS in the primary sludge going to the digester. Or did it?

There are a couple of very important assumptions that are made when it comes to solids removal in primary clarifiers and primary sludge concentrations. All operators need to fully understand these assumptions and the impacts of them on downstream processes, both in the liquid and solids treatment trains. These are:

1. TSS and VSS are removed in primary clarifiers at the exact same rate.
2. TSS and VSS removed from primary clarifiers are treated as TS and VS in primary sludge.

The first of these assumptions means that the percent volatile solids in the primary influent is the same percent volatile solids in the primary effluent and the percent volatile solids in the primary sludge. It also means that the VSS removal efficiency in primary clarifiers is the same as the TSS removal efficiency if given or calculated.

The second of these assumptions means that the TSS and VSS removed from the influent are the TS and VS applied to the digesters in the primary sludge flow.

Again, all operators need to fully understand these assumptions and the impacts of them on downstream processes, both in the liquid and solids treatment trains.

The problem gives us the %VS in the digested biosolids: 52.1%.

We have to calculate the %VS in the primary sludge using the influent TSS and VSS concentrations and the two assumptions we just reviewed.

$$\text{Influent volatile solids, \%} = \frac{263\ \text{~~mg VSS~~/~~L~~} \times 100}{355\ \text{~~mg TSS~~/~~L~~}} = 74.1\%$$

The first assumption says that the percent VSS in the influent is the same as the percent VSS in the primary sludge.

The second assumption says that the VSS removed in the primary clarifiers becomes VS in the primary sludge, meaning the percent VS in the primary sludge is 74.1%.

Now we have the numbers we need (remember decimals!):

1. $.VS_{in} = 0.741$
2. $.VS_{out} = 0.521$

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$$\text{VSR, \%} = \frac{(0.741 - 0.521) \times 100}{0.741 - (0.741 \times 0.521)}$$

VSR = **<u>62.0%</u>**.

Discussion

What does the VSR mean? A VSR of 62.0%, for example, means that for every 100 pounds of VS applied or fed to the digester, 62.0 pounds are destroyed. Well, not really “destroyed” because the carbon in the VS that are destroyed (reduced) is converted to methane (CH_4) and carbon dioxide (CO_2) in the digester gas. The reason we use the word “destroyed” is because digester gas production is often expressed as cubic feet of gas produced per pound of volatile solids destroyed. The way WWTT expresses the VSR when doing digester gas problems is, for example, 62.0 lb $VS_{destroyed}$/100 lb $VS_{applied}$. This labeling is very, very useful when doing digester gas problems.

Notice how much of the information given in the problem that wasn’t used. Certification exam questions are always trying to throw you off track. The only way to be absolutely certain they won’t: **know your stuff!**

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.