Problem of the Day
2014.Nov.06

Discussion

The Water Environment Federation is the trade organization for water professionals, including wastewater treatment operations professionals (http://wefcom.wef.org/home). Individual states, or groups of states, sponsor local chapters. On October 29, 2014, I gave a 6-hour Math for Operators Workshop at the annual conference of the Pacific Northwest Clean Water Association (PNCWA). PNCWA represents Idaho, Oregon and Washington (http://www.pncwa.org/). All operators should seriously consider joining their local association. In California it is the California Water Environment Association (http://www.cwea.org/).

Long story short: I randomly covered a series of math problems in the PNCWA workshop, and I have been requested by several attendees to send them the problems. Instead, I am going to post them here (starting with the 2014.Nov.04 Problem of the Day). They are good practice for all visitors to WWTT's Problem of the Day.

For those of you who may be new to WWTT's Problem of the Day, we insert a page break after the problem statement so you can print it without looking at the solution: see what you can do to solve the problem **before** looking at the solution.

Problem

To do today's problem there are some assumptions we have to make as discussed further below.

Problem of the Day: Given the following information, calculate the pounds of VS per day in the primary sludge going to the anaerobic digesters.

- Influent flow = 6.1 MGD
- Primary influent TSS = 250 mg TSS/L
- Primary influent VSS = 181 mg VSS/L
- Primary effluent TSS = 87 mg TSS/L
- **Calculate: lb VS/d** in the primary sludge to the anaerobic digesters.

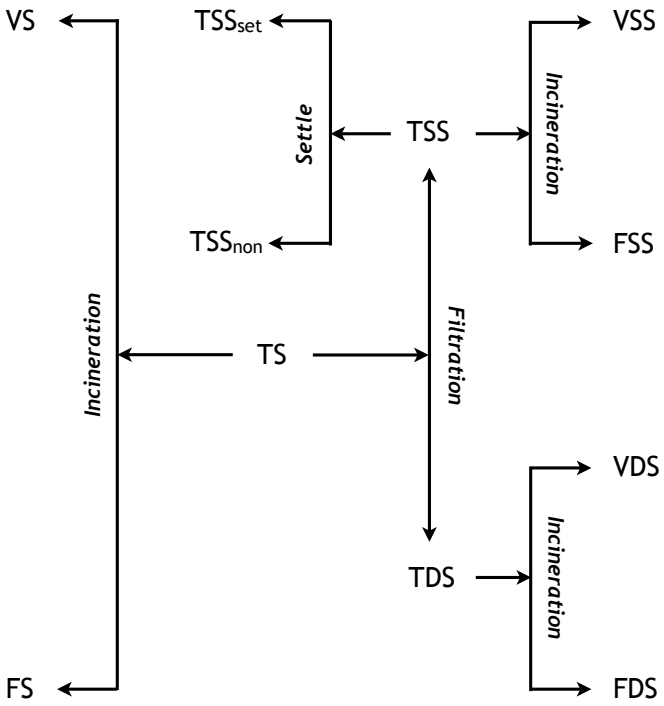
Solution

There are two assumptions we have to make to solve this and similar problems that are very important to emphasize and understand. First, we assume that **TSS and VSS are removed in primary clarifiers in the same proportions**. For example, the TSS removal efficiency across the primary clarifier in this problem is:

$$\text{Removal efficiency (\%)} = \left| \frac{(250 - 87)\ \cancel{\text{mg TSS/L}}}{250\ \cancel{\text{mg TSS/L}}} \right| 100 = 65.2\%$$

The assumption we're making to do these problems— that TSS and VSS are removed across primary clarifiers in the same proportions—means that the VSS removal efficiency across this primary clarifier also is 65.2%. This is important because we can't calculate the VSS concentration in the primary sludge without making this assumption, based on what is given in the problem. Also, this assumption means the volatile content is the same in the influent solids, the primary effluent solids and the primary sludge solids. In this problem, the volatile content of the influent solids is (181/250) x 100 = 72.4%. This assumption means that the primary effluent and primary TSS also are 72.4% VSS. This assumption also was discussed in the 2014.Oct.25 Problem of the Day (http://wastewatertechnologytrainers.com/wp-content/uploads/2014/10/2014.Oct_.25.pdf).

The following graphic was posted in the 2014.Oct.25 Problem of the Day.



*Solids of interest in wastewater treatment: Total Solids (**TS**), Volatile Solids (**VS**), Fixed Solids (**FS**), Total Suspended Solids (**TSS**), Volatile Suspended Solids (**VSS**), Fixed Suspended Solids (**FSS**), Settleable TSS (**TSS$_{set}$**), Non-settleable TSS (**TSS$_{non}$**), Total Dissolved Solids (**TDS**), Volatile Dissolved Solids (**VDS**), and Fixed Dissolved Solids (**FDS**); **Incineration** at 550°C, **Filtration** through 1.2-um filter, **Settle** for 30 minutes.*

This graphic shows that, by filtration, we separate total solids (TS) into total suspended solids (TSS) and total dissolved solids (TDS). In other words, TS = TSS + TDS. The graphic also shows, a little less directly, that VS = VSS + VDS. **But**, we make the assumption when doing primary sludge problems that **TS = TSS** and **VS = VSS**. Since we don't know what the TDS concentration is, and rarely do, this assumption is necessary to do these kinds of problems.

There are two ways to do this problem: (1) use the percent VSS in the influent solids, the effluent solids and the primary sludge calculated above, and (2) use the TSS/VSS removal efficiency also calculated above.

Problem of the Day: Given the following information, calculate the pounds of VS per day in the primary sludge going to the anaerobic digesters.

- Influent flow = 6.1 MGD
- Primary influent TSS = 250 mg TSS/L
- Primary influent VSS = 181 mg VSS/L
- Primary effluent TSS = 87 mg TSS/L
- ⋆ TSS concentration to primary sludge = (250 − 87)mg TSS/L = 163 mg TSS/L
- ⋆ TSS, and VSS, removal efficiency = 65.2% = 0.652 (from above)
- ⋆ Influent TSS = 72.4% VSS (from above) = 72.4 lb VSS/100 lb TSS
- **Calculate: lb VS/d** in the primary sludge to the anaerobic digesters.

lb VS	=	72.4 **lb VS**(S)	163 ~~mg~~ ~~TSS~~	~~L~~	6.1 ~~Mgal~~	8.34 ~~lb~~
d		100 ~~lb~~ ~~TSS~~	~~L~~	~~M·mg~~	**d**	~~gal~~

The first railroad track entry on the right-hand side of the equals sign is the percent VS(S) in the influent solids. Notice the second S in **VS**(S) is in parentheses. This is my way of saying, “I know VSS doesn’t equal VS, but I’m making the assumption they are, which is standard practice.”

All the units have canceled except those needed in the answer, **lb VS/d**. The arithmetic gives the answer:

72.4 x 163 x 6.1 x 8.34 ÷ 100 = **6,004 lb VS/d**.

Problem of the Day: Given the following information, calculate the pounds of VS per day in the primary sludge going to the anaerobic digesters.

- Influent flow = 6.1 MGD
- Primary influent TSS = 250 mg TSS/L
- Primary influent VSS = 181 mg VSS/L
- Primary effluent TSS = 87 mg TSS/L
- ⋆ TSS concentration to primary sludge = (250 − 87)mg TSS/L = 163 mg TSS/L
- ⋆ TSS, and VSS, removal efficiency = 65.2% = 0.652 (from above)
- ⋆ Influent TSS = 72.4% VSS (from above) = 72.4 lb VSS/100 lb TSS
- **Calculate: lb VS/d** in the primary sludge to the anaerobic digesters.

lb VS	=	181 ~~mg~~ **VS**(S)	0.652	~~L~~	6.1 ~~Mgal~~	8.34 ~~lb~~
d		~~L~~		~~M·mg~~	**d**	~~gal~~

Again, notice the second S in **VS**(S) is in parentheses. This is my way of saying, “I know VSS doesn’t equal VS, but I’m making the assumption they are, which is standard practice.”

All the units have canceled except those needed in the answer, **lb VS/d**. The arithmetic gives the answer:

181 x 0.652 x 6.1 x 8.34 = **6,004 lb VS/d**.

Has to be the same answer because of the assumptions we made.

Happy calculating!