Problem of the Day

2014.Dec.19

Introduction

I have always heard that the Chinese character meaning "crisis" is two characters superimposed on each other. The first, taken by itself, means "danger." The second, taken by itself, means "opportunity." With the drought in California, we have certainly been in crisis mode. But what amazing opportunity! **It is a good time to be in the water business**. We really can live without oil. It's impossible to live without water.

But the water business is getting more and more sophisticated. So much of protecting the public's health rests on the shoulders of water and wastewater treatment plant operators. We also must do our jobs as cost effectively as possible to protect our ratepayers' hard earned money. Our jobs aren't just about "meeting permit." Consider this, or something like it, as the professional operator's credo:

> **The mission of wastewater treatment plant operators is to remove pollutants from the incoming water while complying with all permit requirements—water, land and air—and convert them to safe disposable biosolids as sustainably and cost effectively as possible.**

How do we prove to our ratepayers, regulators and ourselves that we're up for the task: **by attaining increasing levels of certification**.

At the heart of wastewater treatment is nutrient and pathogen removal. Let's talk about nutrients. Today when we hear "nutrients," most of us think about nitrogen (N) and phosphorus (P), but there is a third nutrient that has defined wastewater treatment from the beginning: carbon (C). Yes, carbon. The massive, indiscriminate release of carbon into our waterways—specifically, organic carbon—during the 100+ years leading up to the passage of the Clean Water Act in 1972 in the United States didn't lead to the algae blooms and euthrophication we associate with N and P release. Instead, the oxidation of all that carbon by resident microorganisms led to dissolved oxygen (DO) "sag" and fish suffocated.

We indirectly measure the presence, or absence, of organic carbon by a number of analytical tests: BOD, CBOD, COD, TOC (total organic carbon), VSS and VS. All of these tests are measurements of "organics" in a sample. Indeed, "organic" is synonymous with "organic carbon."

Primary clarifiers remove more organics for less money than any other process unit at a wastewater treatment plant. The process objective of primary clarification is the removal of settleable total suspended solids (TSS_{set}). The BOD (or COD) associated with those solids is removed when the solids are removed. This is important. The reason it is important is because secondary treatment, where the remaining BOD is "removed" (I will explain "removed" in a subsequent post), is expensive, so **the more BOD removed in the primary clarifiers, the better**.

Indeed, wastewater treatment **is** expensive (see operator's credo above: "... as cost effectively as possible."). The organic carbon captured by primary clarifiers, measured in terms of BOD, COD, or VS, can be converted to methane in anaerobic digesters that can then be burned in engines driving electrical generators. Augmenting the organic carbon captured in primary clarifiers, some plants feed fats, oils and grease (FOG) to their digesters to increase methane production and electricity generation. East Bay Municipal Utilities District (EMBUD) has been so successful doing so, they produce more electricity than they use. **This is the future**.

Problem of the Day

The Running Springs wastewater treatment plant receives an average dry weather flow of 2.5 MGD. The peak wet weather flow is 8 MGD. There are two primary clarifiers, each is 60 feet in diameter with an average depth of 16.5 feet. There is a single effluent weir around the periphery of each primary clarifier. The average influent TSS and BOD concentrations during dry weather flow are 325 and 350 mg/L, respectively. The influent TSS are 72% volatile. The average primary effluent TSS and BOD concentrations during dry weather flow are 105 and 205 mg/L, respectively. Each primary sludge pump pumps 30 gpm. What is the VSS concentration in the influent?

Discussion

Because primary clarifiers are such treatment plant workhorses, operators really need to "get their heads around them." We're going to use this same problem statement and do every primary clarifier type problem we can think of, maybe even make up a few! We'll keep track of the types of problems in the following list so you can refer back to individual Problems of the Day if you have a question on a specific type of primary clarifier problem.

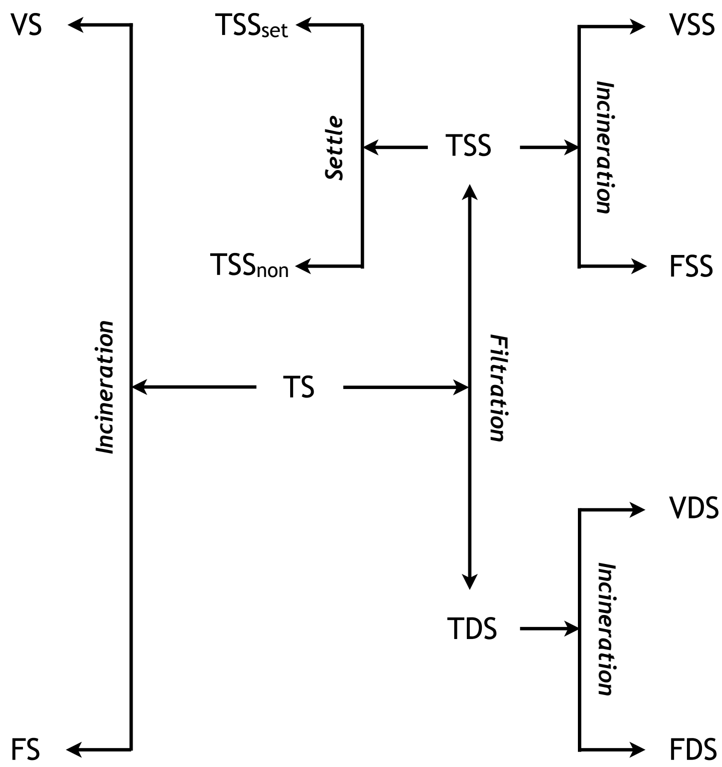
- 2014.Dec.16—TSS removal efficiency
- 2014.Dec.17—BOD removal efficiency
- 2014.Dec.18—VSS removal efficiency
- 2014.Dec.19—influent VSS concentration

In today's problem we're asked to calculate the VSS concentration in the influent to the primary clarifiers.

Three important points have been made in previous Problems of the Day that operators need to fully understand:

1. We make the assumption, always, that the VSS removal efficiency in primary clarifiers equals the TSS removal efficiency (but **never** the BOD or TSS_{set} removal efficiencies).
2. On account of this assumption, the percent volatile solids in the influent remains the same in the primary effluent and in the primary sludge.
3. VSS and particulate BOD both measure the same material but, because the two tests are conducted completely differently, they will not be numerically equal.

The different solids of interest in wastewater treatment are a source of confusion for many operators. WWTT uses the figure below to try to sort out this confusion.



*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.*

Notice in this figure that VS are a “subset” of TS, VSS are a “subset” of TSS, and VDS are a “subset” of TDS. The definition is the same for VS, VSS, and VDS: those TS, TSS, and TDS, respectively that burn away at 550°C. All are “organic:” organic total solids, organic suspended solids, and organic dissolved solids, respectively.

Solution

The influent VSS are a part (“subset”) of the influent TSS. Because the part has to be less than the whole, the VSS concentration is determined simply by multiplying the TSS concentration by the decimal percentage of VSS.

Problem of the Day: The Running Springs wastewater treatment plant receives an average dry weather flow of 2.5 MGD. The peak wet weather flow is 8 MGD. There are two primary clarifiers, each is 60 feet in diameter with an average depth of 16.5 feet. There is a single effluent weir around the periphery of each primary clarifier. The average influent TSS and BOD concentrations during dry weather flow are 325 and 350 mg/L, respectively. The influent TSS are 72% volatile. The average primary effluent TSS and BOD concentrations during dry weather flow are 105 and 205 mg/L, respectively. Each primary sludge pump pumps 30 gpm. What is the VSS concentration in the influent?

Information summary, specifically labeled (**bold** indicates used in today’s problem):

- Average dry weather flow = 2.5 MGD
- Peak wet weather flow = 8 MGD
- Number of primary clarifiers = 2 PC
- Primary clarifier diameter = 60 ft
- Primary clarifier depth = 16.5 feet
- Primary influent dry weather TSS = **325 mg TSS/L**
- Primary influent dry weather BOD = 350 mg BOD/L
- Primary influent TSS = 72% VSS = **72 mg VSS/100 mg TSS**
- Primary effluent dry weather TSS = 105 mg TSS/L
- Primary effluent dry weather BOD = 205 mg BOD/L
- Primary sludge pumps, each = 30 gal sldg/min
- Calculate: **influent VSS concentration in mg VSS/L**.

mg VSS	=	72 mg VSS	325 ~~mg TSS~~
L		100 ~~mg TSS~~	**L**

72 x 325 ÷ 100 = **<u>234 mg VSS/L</u>**.

Math is not random. Use units, PRACTICE, and you will succeed.

Notice how the VSS percentage, 72%, is expressed in the problem information: 72 mg VSS/100 mg TSS. It could have been 72 lb VSS/100 lb TSS or 72 tons VSS/100 tons TSS or 72 kg VSS/100 kg TSS. It doesn’t matter as long as units of weight, or mass, are used. In water and wastewater math, percent is almost always given on a **weight** basis. A notable exception to this is when we’re talking about digester gas. When the methane (CH_4) content of digester gas is given as 62%, it is on a **volume** basis and WWTT expresses it as 62 ft^3 CH_4/100 ft^3 of gas.

Happy calculating. Let us know, by leaving a comment, if you want us to do a specific problem or if you see a mistake.