Problem of the Day

2014.Dec.23

Introduction

I understand 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 measure "organics" in a sample. "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 but it is our job to treat wastewater " as cost effectively as possible." The organic carbon captured by primary clarifiers 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 (EBMUD) has been so successful doing so, they produce more electricity than they use. **This is the future**.

For those of you who may be new to WWTT's Problem of the Day, we insert a page break before and 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 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. How many pounds of VSS per day does the plant receive during dry weather?

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
- 2014.Dec.20—primary effluent VSS concentration
- 2014.Dec.21—primary sludge volatile content (VS and VSS)
- 2014.Dec.22—influent TSS pounds per day
- 2014.Dec.23—influent VSS pounds per day

In today's problem we are asked to calculate the VSS load to the plant. Whenever reference is made to "load," by definition, pounds per day (lb/d) are implied.

Solution

The primary influent VSS are a part ("subset") of the primary 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, expressed here, as WWTT commonly does, as "parts per 100 parts," which is the definition of percent. The units needed in the answer, lb VSS/d, are shown between heavy vertical lines followed by the equals sign and the blank track to get the problem started.

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. How many pounds of VSS per day does the plant receive during dry weather?

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

- **Average dry weather flow = 2.5 Mgal/d**
- Peak wet weather flow = 8 Mgal/d
- Number of primary clarifiers = 2 PC
- Primary clarifier diameter = 60 ft
- Primary clarifier depth = 16.5 ft
- 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: **lb VSS/d in the primary influent**.

$$\left|\frac{\text{lb VSS}}{\text{d}}\right| = \underline{\hspace{8cm}}$$

The railroad track is started with the unit, **VSS**, needed in the answer, and it only shows up in the list of information given in one place: **72 mg VSS/100 mg TSS** (percent influent VSS expressed as parts per 100 parts). This is used to start the railroad track.

lb **VSS**	=	72 mg **VSS**				
d		100 mg TSS				

We have to cancel the **mg TSS** with the influent TSS concentration since it is the influent VSS load we are calculating.

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

There is mg and L that must be canceled. WWTT recommends they be canceled with the conversion factor, **M•mg/L**, unless the problem is solving for mg/L. Notice that **M•mg/L** is entered into the railroad track to cancel **mg** and **L**.

lb **VSS**	=	72 ~~mg~~ **VSS**	325 ~~mg TSS~~	~~L~~		
d		100 ~~mg TSS~~	~~L~~	M·~~mg~~		

The **M** that remains in the denominator is a reminder that an **Mgal** is needed in the numerator to cancel the **M**s. We have two **Mgals** given in the problem, but since we're calculating the VSS load (**lb VSS/d**) during dry weather so we use the dry weather flow

lb **VSS**	=	72 ~~mg~~ **VSS**	325 ~~mg TSS~~	~~L~~	2.5 ~~M~~gal	
d		100 ~~mg TSS~~	~~L~~	~~M·mg~~	**d**	

We have a **gal** to cancel and we need **lb** in the numerator of the answer so it has to be entered in the railroad track. We "kill two birds with one stone" by entering the density of water. Notice that the unit, **lb**, has to go in the numerator so that tells us how the density has to be entered into the railroad track.

lb VSS	=	72 ~~mg~~ **VSS**	325 ~~mg TSS~~	~~L~~	2.5 ~~Mgal~~	8.34 **lb**
d		100 ~~mg TSS~~	~~L~~	~~M·mg~~	**d**	~~gal~~

In the railroad track we now have only the units needed in the answer, **lb VSS/d**, so we **know** the math is done.

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. How many pounds of VSS per day does the plant receive during dry weather?

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- Primary clarifier diameter = 60 ft
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- **Primary influent dry weather TSS = 325 mg TSS/L**
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- **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: **lb VSS/d in the primary influent**.

$$\frac{\textbf{lb VSS}}{\textbf{d}} = \frac{72\ \cancel{\text{mg}}\ \textbf{VSS}}{100\ \cancel{\text{mg TSS}}} \cdot \frac{325\ \cancel{\text{mg TSS}}}{\cancel{\text{L}}} \cdot \frac{\cancel{\text{L}}}{\cancel{\text{M·mg}}} \cdot \frac{2.5\ \cancel{\text{Mgal}}}{\textbf{d}} \cdot \frac{8.34\ \textbf{lb}}{\cancel{\text{gal}}}$$

The arithmetic gives the answer:

72 x 325 x 2.5 x 8.34 ÷ 100 = **4,879 lb VSS/d**.

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