The Napa "Great Shake" Solution Sheet

WARM-UP

Calculating hydraulic detention time and organic loading are two important factors treatment plant operators have to understand in order to operate a wastewater treatment plant.

Hydraulic detention time (HDT) also known as hydraulic retention time (HRT) is a measure of the average length of time that a compound (in this case wastewater) remains in a treatment tank or unit. Simply stated if you started to fill a tank with wastewater the detention time is the average amount of a time that a drop of that water will remain in the treatment tank before the tank fills and that drop of water flows out of it. This is important because as wastewater passes through a treatment tank it must stay in the tank for the necessary period of time in order to be adequately treated. For example, in most aeration treatment systems, 4 to 8 hours of detention time is necessary in order for the microorganisms in the aeration system to absorb, adsorb and remove the contaminants (bacteria food) in the wastewater.

Like humans, animals and other organisms, the microorganisms used to treat wastewater need the right amount of food in order to survive and thrive. Organic loading in wastewater is measured as BOD (Biochemical Oxygen Demand) which is a test run in a lab which measures the concentration or strength of the organic loading of a volume of wastewater. Think of the BOD or organic load as wastewater contamination which serves as bacteria food that the microorganisms in the treatment system consume and remove from the wastewater. Treatment plant operators must understand the relationship between the contaminant (organic load) in the wastewater relative to the amount of microorganisms in the treatment system that are available to remove that organic load. Therefore, operators must calculate the pounds of organic load contained in a volume of wastewater then calculate the pounds of microorganisms that are in the treatment system which is available to consume and remove the organic load. The operator then compares the pounds of organic loading to the pounds of microorganisms. This comparison is referred to as the Food to Microorganism (F/M) ratio. Most treatment plants operate at an F/M ratio of 0.2 to 0.5. This means for every 2 to 5 pounds of organic load in a volume of wastewater the treatment system must contain 10 pounds of microorganisms in order to stabilize and remove that organic load.

1. Hydraulic Detention Time

A. Calculate the Hydraulic Detention Time in a treatment tank given the following:

Flow to a rectangular aeration basin is 3.0 million gallons per day. The clarifier is 100 ft in length, 50 ft wide, and 15 ft deep. Calculate the aeration basin's hydraulic detention time.

$$\frac{(100 \times 50 \times 15)\ ft^3 * 7.5\ gal/ft^3 * 24\ hrs/day}{3{,}000{,}0000\ gal/day}$$

$$\frac{75000\ ft^3 * 7.5\ gal/ft^3 * 24\ hrs/day}{3{,}000{,}000\ gal/day}$$

$$\frac{13{,}500{,}000\ gal/hrs/day}{} = 4.5 hrs$$

3,000,000 gal/day

B. Is this an adequate amount of treatment time?

Yes the normal range is 4 to 8 hours

2. Organic Loading

a. Convert a concentration of wastewater contaminants to pounds.

i. A wastewater flow rate is 6 MGD (million gallons/day) has an organic loading concentration of 250 mg/l BOD (Biochemical Oxygen Demand).

12,510 = 8.34 (lbs*L/MG*mg) x 6 MGD x 250 mg/l

b. Determine microorganism population in pounds.

i. A wastewater treatment tank has a volume of 3.0 (MG) million gallons and has a solids concentration of 2500 mg/l (parts per million). The solids are 81% volatile (microorganisms).

{lbs/day} = 8.34 [lbs x L/MG x mg] x Vol, [MGD] x conc, [mg/L] x % Volatile.

= 8.34 (lbs x L/MG x mg) * 3MG * 2500 mg/l * 81%

50,665.5 = 8.34 (lbs x L/MG x mg) * 3MG * 2500 mg/l * 0.81

c. Comparing pounds of wastewater contamination to pounds of bacteria in the treatment system what is the Food to Microorganism Ratio?

0.24 = **12,510 lbs of Wastewater Contaminants**

50,665 Lbs of Treatment Microorganisms

(Normal Food to Microorganism Ratio is 0.2 to 0.5)

EXIT TICKET

What did you learn about detention and how it is calculated?

What did you learn about organic loading and how it is calculated?

What did you learn about the ratio of food (wastewater contamination) a wastewater treatment bacteria will consume relative to its body mass?

Did you find the concepts difficult to understand?

What aspect of this problem(s) was difficult to understand?

Given what we have reviewed about how wastewater is treated how do you suppose 360,000 gallons of wine spilled and flowing to the wastewater plant at the City of Napa's wastewater plant impacted the operation of wastewater treatment plant?

The Napa Shake Up

Wastewater treatment plant operators have to make numerous calculations in order to make adjustments to treatment processes. Two of those calculations are hydraulic detention time which is a measure of the average amount of time a volume of wastewater is in a treatment unit. Wastewater treatment plants use microorganisms in the treatment process. These microorganisms consume contaminants in the wastewater using that contamination as their food source. Operators most insure that there is the proper amount of microorganisms in order to remove the contaminants in the incoming wastewater. Therefore, wastewater operators must calculate the food to microorganism (F/M) ratio.

The City of Napa Wastewater Treatment Plant operates well with an historically established a determined hydraulic detention time and organic loading rate (Food/Microorganism Ratio). As a result of the Napa Earthquake staff estimates that approximately 360,000 gallons of wine spilled and made its way into the wastewater treatment plant. This 360,000 gallons impacted both the detention and organic loading (Food to Microorganisms ratio).

If we assume the following:

Normal Flow: 6 million gallons per day

Normal Flow BOD: 250 mg/l

Aeration Total Volume: 3 million gallons

Aeration Mixed Liquor Suspended Solids: 2500 mg/l

Volatile Content: 81% (% of material in the treatment unit that is organic. i.e. bacteria)

Normal Detention Time: 4.5 hours

Normal Food/Microorganism Ratio: 0.24

Refer to the warm-up exercise where the normal detention time and food to microorganism ratio was determined for the City of Napa's Wastewater Treatment Plant. August 24, 2014 the *South Napa Earthquake* resulted in a spill of 360,000 of wine making its way into the City of Napa's sewer and eventually that wine along with the normal wastewater flowed into the Napa Wastewater Treatment Plant.

If 360,000 gallons of wine with a BOD (biochemical oxygen demand) content of 11,500 mg/l flows into the treatment plant along with the normal wastewater flow:

1. What is the impact on treatment detention time in the aeration system? Normal Range is 4 to 8 hours. (Refer to Warm-up Exercise 1A)

$$\frac{\textbf{13,500,000 gal/hrs/day}}{\textbf{3,000,000 gal/day}} = \textbf{4.5hrs}$$

$$\frac{\textbf{13,500,000 gal/hrs/day}}{\textbf{3,360,000 gal/day}} = \textbf{4.0hrs}$$

2. What do you think the operator may have to do in order to adapt to this change?

No action required in regards to detention time. Detention time dropped from 4.5 hours to 4.0 hours but it is still within the target range for detention time which is 4 to 8 hours.

3. What is the impact on treatment food to microorganism ratio? Normal Range is 0.2 to 0.5.

$$\{lbs/day\} = 8.34\ \{lbs \cdot L/MG \cdot mg\} \times Q,\{MGD\} \times conc,\{mg/L\}$$

12,510 lbs = 8.34 (lbs*L/MG*mg) x 6 MGD x 250 mg/l - normal WW organic load (see warmup exercise 2a.)

34,527.6 lbs = 8.34 (lbs*L/MG*mg) x 0.360 MGD x 11500 mg/l – Wine Spill organic load

12,510 lbs(normal) + 34,527.6 lbs(wine) = <u>47,037.6</u> lbs of organic loading measured as BOD (Bacteria Food)

{lbs/day} = 8.34 [lbs x L/MG x mg] x Vol, [MGD] x conc, [mg/L] x % Volatile.

= 8.34 (lbs x L/MG x mg) * 3MG * 2500 mg/l * 81%

<u>50,665.5</u> = 8.34 (lbs x L/MG x mg) * 3MG * 2500 mg/l * 0.81 (see warmup exer. 2b.)

0.92 = <u>47,036.6 lbs of organic load</u>

50,665.5 lbs of microorganisms

4. What do you suspect the operators at Napa needed to do in order to adapt to this change in food to microorganism ratio?

- **Add more treatment bacteria to the system**
- **Divert wastewater contaminated with wine to holding tanks a slowly bring through the treatment facility.**

- **Increase air(oxygen) , nutrients and other things necessary for microbial growth and metabolism**