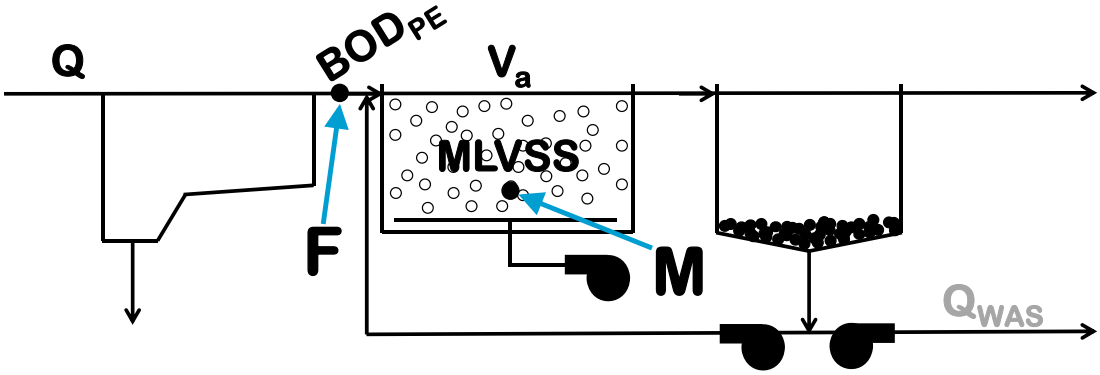
Problem of the Day

2014.Oct.31

Discussion

In the 2014.Oct.05 Problem of the Day (http://wastewatertechnologytrainers.com/wp-content/uploads/2014/10/2014.Oct_.05.pdf), the following schematic was given summarizing the information needed to calculate and control the F/M ratio in an activated sludge system, often asked on wastewater certification exams.



Activated sludge process schematic showing needed information to calculate the F/M ratio.

While a discussion for another day, operators should understand, although they are rarely told so, that the **mass of MLVSS** in an activated sludge system is **fixed** by the growth rate of the microorganisms, the BOD load and the temperature of the wastewater. **This is important because the growth rate is fixed by the MCRT (or SRT)**, which is why the MCRT is the most important parameter that an activated sludge operator controls. With all of this said, readers should realize that the microorganisms, not the operators or engineers, control their mass because only they know exactly how much BOD is coming into the aeration basin. **Make no mistake about it, the F/M ratio should not be used as an activated sludge control parameter**. Still, we have to be able to calculate it.

Problem

Today's problem is a straightforward F/M ratio calculation.

Problem of the Day: The flow to the Enfield WWTP is 3.25 Mgal/d. There are three on-line aeration basins each 142 feet long, 20 feet wide and 16 feet deep. The MLSS concentration is 1,800 mg/L and is 72.5% volatile. The primary effluent BOD concentration is 145 mg/L. Calculate the F/M ratio.

Solution

It is helpful to list the information given in the problem statement:

- Q = 3.25 Mgal/d
- Primary effluent BOD = 145 mg BOD/L
- Three aeration basins (3 AB)
- Aeration basin length = 142 ft
- Aeration basin width = 20 ft
- Aeration basin depth = 16 ft
- MLSS = 1,800 mg MLSS/L
- MLVSS is 72.5% of MLSS
- MLVSS = 0.725 x 1,800 = 1,305 mg MLVSS/L

WWTT recommends that F and M be calculated separately. Again, these are defined as follows:

F = **pounds per day** of BOD entering the aeration basin

M = **pounds** of MLVSS

As can be seen, determining F is a pounds-per-day calculation; determining M is a pounds calculation. The difference is that flow is used in a pounds-per-day calculation (F) and volume is used in a pounds calculation (M). The F and M calculations are defined in "equation railroad tracks" as follows:

$$\left|\frac{F\ \mathbf{lb\ BOD}}{\mathbf{d}}\right| = \left|\frac{BOD_{PE}\ \cancel{mg}\ \mathbf{BOD}}{\cancel{L}}\ \frac{\cancel{L}}{\cancel{M \cdot mg}}\ \frac{Q\ \cancel{Mgal}}{\mathbf{d}}\ \frac{8.34\ \mathbf{lb}}{\cancel{gal}}\right|$$

$$\left|M\ \mathbf{lb\ MLVSS}\right| = \left|\frac{\mathbf{MLVSS}\ \cancel{mg}}{\cancel{L}}\ \frac{\cancel{L}}{\cancel{M \cdot mg}}\ \frac{V_a\ \cancel{Mgal}}{}\ \frac{8.34\ \mathbf{lb}}{\cancel{gal}}\right|$$

Once F and M have been determined using these equations, the F/M ratio is easily calculated:

$$\left|\frac{F}{M}\right| = \left|\frac{F\ lb\ BOD}{d}\ \frac{}{M\ lb\ MLVSS}\right|$$

Repeating the problem statement:

Problem of the Day: The flow to the Enfield WWTP is 3.25 Mgal/d. There are three on-line aeration basins each 142 feet long, 20 feet wide and 16 feet deep. The MLSS concentration is 1,800 mg/L and is 72.5% volatile. The primary effluent BOD concentration is 145 mg/L. Calculate the F/M ratio.

F and M are calculated using the equation railroad tracks given above.

$$\left|\frac{F\ lb\ BOD}{d}\right| = \left|\frac{145\ \cancel{mg}\ BOD}{\cancel{L}}\ \frac{\cancel{L}}{\cancel{M \cdot mg}}\ \frac{3.25\ \cancel{Mgal}}{d}\ \frac{8.34\ lb}{\cancel{gal}}\right|$$

The arithmetic: F = 145 x 3.25 x 8.34 = 3,930 lb BOD/d.

In calculating M, the volume of the aeration basins has to be converted first to gal then to Mgal to "work" in the pounds equation (remember, the M in M·mg is canceled with the M in Mgal). Also, the concentration

of MLVSS was calculated above using the MLSS concentration and the percent volatile (0.725 x 1,800 = 1,305 mg MLVSS/L).

$$\left|\text{M lb MLVSS}\right| = \left|\frac{1{,}305\ \cancel{\text{mg}}\ \textbf{MLVSS}}{\cancel{\text{L}}}\ \frac{\cancel{\text{L}}}{\cancel{\text{M}\cdot\text{mg}}}\ \frac{142\ \cancel{\text{ft}}}{\cancel{\text{AB}}}\ \frac{20\ \cancel{\text{ft}}}{}\ \frac{16\ \cancel{\text{ft}}}{}\ \frac{3\ \cancel{\text{AB}}}{}\ \frac{7.48\ \cancel{\text{gal}}}{\cancel{\text{ft}^3}}\ \frac{\cancel{\text{Mgal}}}{10^6\ \cancel{\text{gal}}}\ \frac{8.34\ \textbf{lb}}{\cancel{\text{gal}}}\right|$$

The arithmetic: M = 1,305 x 142 x 20 x 16 x 3 x 7.48 x 8.34 ÷ 1,000,000 = 11,098 lb MLVSS.

With F and M known, the F/M calculation is very straightforward using the equation railroad track given above and demonstrated below.

Problem of the Day: The flow to the Enfield WWTP is 3.25 Mgal/d. There are three on-line aeration basins each 142 feet long, 20 feet wide and 16 feet deep. The MLSS concentration is 1,800 mg/L and is 72.5% volatile. The primary effluent BOD concentration is 145 mg/L. Calculate the F/M ratio.

$$\left|\frac{F}{M}\right| = \left|\frac{3{,}930\ \text{lb BOD}}{\text{d}}\ \frac{}{11{,}098\ \text{lb MLVSS}}\right|$$

The arithmetic: F/M = 3,930 ÷ 11,098 = **<u>0.35 lb BOD/d•lb MLVSS</u>**.

Important: The F/M ratio has units, so it is NOT unitless, although it is often reported as such; the units on the F/M ratio are lb <u>BOD/d•lb MLVSS</u>.