Problem of the Day

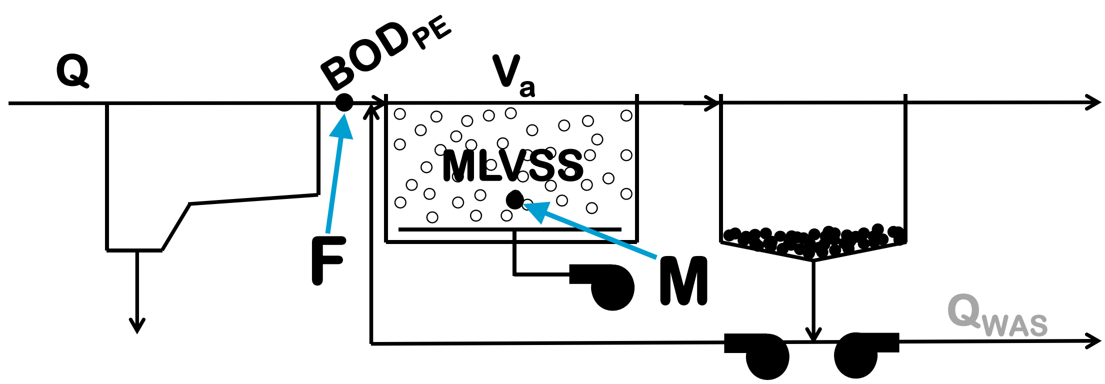
**2014.Oct.05**

## Discussion

In yesterday's Problem of the Day, the importance of the MCRT, or its mathematically similar SRT, to activated sludge process control was stressed. The post ended with, "**Again, the MCRT, or SRT, is the most important parameter that an activated sludge operator controls**." While many books, training materials, trainers, instructors, what have you, will preach that activated sludge operators have to "keep an eye on many parameters like the MCRT (or SRT), the MLSS concentration, the MLVSS concentration, the system mass, and the F/M ratio," please, please, please understand that **all of these are controlled by the MCRT**. All of this can be proven mathematically. Besides controlling these, the MCRT also controls sludge quality (how the activated sludge flocculates, settles and compacts in the secondary clarifier) and whether or not the activated sludge system will nitrify.

Most state certification exams require operators to be able to calculate the F/M ratio and to use it to determine how many pounds of biomass, or "microorganisms," are needed in the aeration basin for the amount of BOD, or "food," per day that is entering the aeration basin. **The reality is, neither operators nor engineers control the amount of biomass in an activated sludge system, the microbes do**. Still, we have to be able to calculate F/M and use it to "control" the activated sludge process, so today's Problem of the Day demonstrates the calculation.

The following schematic summarizes the information needed to calculate and control the F/M.




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

## Problem

The MCRT, or SRT, is the **most important** parameter that an activated sludge operator controls, but you need to be able to work with F/M, too. For the exams, not in real life....

**Problem of the Day**: The aeration basin volume at the Muddy Creek WWTP is 0.9 Mgal. The influent flow is 2.7 MGD with 265 mg BOD/L. The primary clarifier removes 38% of the BOD. Calculate the F/M ratio if the MLVSS concentration is 1,520 mg/L.

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

- Q = 2.7 Mgal/d
- $BOD_{INF}$ = 265 mg BOD/L
- BOD removal in primary clarifier = 38%
- BOD passing through primary clarifier = (100 − 38)% = 62% = 0.62
- $V_a$ = 0.9 Mgal
- MLVSS = 1,520 mg MLVSS/L

The F/M ratio is just two pounds calculations. Most of the time the F/M ratio is reported as if it does not have units associated with it. This is completely false. **The units on the F/M ratio are lb/BOD/d•lb MLVSS**.

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

The F and M calculations are defined in “equation railroad tracks” as follows:

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

$$\text{M lb MVLSS} = \frac{\text{MVLSS}\ \cancel{\text{mg}}}{\cancel{\text{L}}} \cdot \frac{\cancel{\text{L}}}{\cancel{\text{M}\cdot\text{mg}}} \cdot \frac{V_a\ \cancel{\text{Mgal}}}{} \cdot \frac{8.34\ \text{lb}}{\cancel{\text{gal}}}$$

Note that $BOD_{PE}$ is the BOD concentration in the primary effluent. If the plant does not have a primary clarifier(s), the influent BOD concentration will be used to calculate F.

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

$$\frac{F}{M} = \frac{F\ \text{lb BOD}}{\text{d}} \cdot \frac{}{\text{M lb MLVSS}}$$

Repeating the problem statement:

**Problem of the Day**: The aeration basin volume at the Muddy Creek WWTP is 0.9 Mgal. The influent flow is 2.7 MGD with 265 mg BOD/L. The primary clarifier removes 38% of the BOD. Calculate the F/M ratio if the MLVSS concentration is 1,520 mg/L.

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

$$\frac{F\ \text{lb BOD}}{\text{d}} = \frac{265\ \cancel{\text{mg}}\ \text{BOD}}{\cancel{\text{L}}} \cdot \frac{0.62}{} \cdot \frac{\cancel{\text{L}}}{\cancel{\text{M}\cdot\text{mg}}} \cdot \frac{2.7\ \cancel{\text{Mgal}}}{\text{d}} \cdot \frac{8.34\ \text{lb}}{\cancel{\text{gal}}}$$

The arithmetic: F = 265 x 0.62 x 2.7 x 8.34 = 3,700 lb BOD/d.

Notice the the influent BOD concentration (265 mg BOD/L) is multiplied by 0.62 to get the primary **effluent** BOD concentration.

$$\left|\text{M lb MVLSS}\right| = \left|\frac{1{,}520\ \cancel{\text{mg}}\ \text{MLVSS}}{\cancel{\text{L}}}\right|\frac{\cancel{\text{L}}}{\cancel{\text{M}\cdot\text{mg}}}\left|\,0.9\ \cancel{\text{Mgal}}\,\right|\frac{8.34\ \text{lb}}{\cancel{\text{gal}}}\right|$$

The arithmetic: M = 1,520 x 0.9 x 8.34 = 11,409 lb MLVSS.

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

$$\left|\frac{\text{F}}{\text{M}}\right| = \left|\frac{3{,}700\ \text{lb BOD}}{\text{d}}\right|\frac{}{11{,}409\ \text{lb MLVSS}}\right|$$

The arithmetic: F/M = 3,700 ÷ 11,409 = 0.32 lb BOD/d·lb MLVSS.

**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 BOD/d·lb MLVSS**.