Settleability Problems and Loss of Solids in the Activated Sludge Process. Michael H. Gerardi

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Appendix I

F/M, HRT, MCRT, MLVSS, Sludge Age, SVI

F/M

The food-to-microorganism ratio or F/M is a measurement of the food entering the activated sludge process and the microorganisms (bacteria) in the aeration tanks. Each activated sludge process has a range of F/M values at which it operates best. The F/M may fluctuate throughout the year according to changes in operational conditions including industrial discharge, permit requirements, or seasonal wastewater temperature. The range of F/M may change on a seasonal basis, for example, higher F/M during the summer and lower F/M during the winter.

The amount of food (**F**) entering the activated sludge process consists of the quantity (loading or pounds) of BOD discharged to the aeration tanks. The BOD loading is calculated by multiplying the concentration (mg/l) of BOD entering the aeration tanks by the influent flow per day (millions of gallons per day, or MGD) to the aeration tanks by the weight constant of 8.34 pounds per gallon of wastewater (Equation I.1).

$$\text{BOD (mg/l)} \times \text{flow (MGD)} \times 8.34\,\text{pounds/gallon of wastewater} = \text{BOD loading} \tag{I.1}$$

The amount of microorganisms (**M**) in the activated sludge process consists of the pounds of mixed liquor volatile suspended solids (MLVSS) in the on-line aeration tanks. The pounds of MLVSS are calculated by multiplying the concentration (mg/l) of MLVSS by the volume of the aeration tanks in million gallons (MG) by the weight constant of 8.34 pounds per gallon of wastewater (Equation I.2).

$$\text{MLVSS (mg/l)} \times \text{aeration tank volume (MG)} \times 8.34\,\text{pounds/gallon of wastewater} = \text{pounds MLVSS} \tag{1.2}$$

The F/M of an activated sludge process can be calculated by dividing the pounds of food as BOD to the aeration tanks by the pounds of microorganisms (bacteria) present in the on-line aeration tanks (Equation I.3). The F/M is simply Equation I.1 divided by Equation I.2.

$$\text{F/M} = \text{pounds BOD to the aeration tank/pounds of MLVSS in the on-line aeration tanks} \quad \text{(I.3)}$$

HRT

The hydraulic retention or HRT of an aeration tank is the amount of time in hours for wastewater to pass through the aeration tank. Changes in HRT can affect biological activity. For example, decreasing HRT adversely affects nitrification and the solubilization of particulate BOD and colloidal BOD. Decreasing HRT also permits the discharge of more BOD to the receiving stream. Increasing HRT favors nitrification and the solubilization of particulate BOD and colloidal BOD. Increasing HRT also permits the discharge of less BOD to the receiving stream.

The HRT of an aeration tank is determined by dividing the volume of the aeration tank (gallons) by the flow rate through the aeration tank (Equation I.4). The flow rate through the aeration tank must be expressed as gallons per hour (gph).

$$\text{HRT (hours)} = (\text{volume of aeration tank, gallons})/(\text{flow rate, gph}) \quad \text{(I.4)}$$

MCRT

The mean cell residence time or MCRT is the amount of time, in days, that solids or bacteria are maintained in the activated sludge process. The MCRT is known also as the solids retention time (SRT). To calculate the MCRT, it is necessary to know the amount of suspended solids (pounds) in the activated sludge process and the amount of suspended solids (pounds) leaving the activated sludge process.

To determine the pounds of suspended solids in the activated sludge process, the pounds of mixed liquor suspended solids (MLSS) must be calculated. The MLSS consists of all solids in the aeration tanks and secondary clarifiers. Therefore, the pounds of MLSS in the activated sludge process consists of the concentration (mg/l) of MLSS times the volume (MG) of the aeration tanks and secondary clarifiers times the weight constant of 8.34 pounds per gallon of wastewater (Equation I.5).

$$\text{Pounds of MLSS} = \text{MLSS (mg/l)} \times (\text{volume of aeration tanks, MG} + \text{volume of secondary clarifiers, MG}) \times 8.34 \text{ pounds/gallon of wastewater} \quad \text{(I.5)}$$

To determine the pounds of suspended solids leaving the activated sludge process, the pounds of suspended solids lost through wasting and discharged in the secondary effluent must be calculated. Therefore, the pounds of suspended solids leaving the activated sludge process consists of pounds of activated sludge wasted

per day and the pounds of activated sludge or secondary effluent solids discharged per day (Equation I.6).

$$\begin{aligned}&\text{pounds of suspended solids leaving the activated sludge process}\\&\quad=\text{wasted sludge (mg/l)}\times\text{wasted flow rate (MGD)}\\&\qquad\times 8.34\,\text{pounds/gallon of wastewater}+\text{secondary effluent solids (mg/l)}\\&\qquad\times\text{effluent flow (MGD)}\times 8.34\ \text{pounds/gallon of wastewater}\end{aligned}\tag{I.6}$$

The MCRT of an activated sludge process can be calculated by dividing the pounds of suspended solids or MLSS in the activated sludge process by the pounds of suspended solids leaving the activated sludge process (Equation I.7). The MCRT is Equation I.5 divided by Equation I.6.

$$\begin{aligned}\text{MCRT}=&\ \text{suspended solids in the activated sludge process/}\\&\ \text{suspended solids leaving the activated sludge process}\end{aligned}\tag{I.7}$$

MLVSS

The mixed liquor volatile suspended solids or MLVSS represents the population size of bacteria within the activated sludge process. Volatile suspended solids are solids that burn in a muffle furnace at 550°C. Although bacteria and other organic materials, for example, grease, oils, and particulate materials, burn in the muffle furnace at 550°C, it is assumed that all volatile solids are bacteria. Therefore, an increase in volatile content of the mixed liquor suspended solids (MLSS) represents an increase in the bacterial population, whereas a decrease in volatile content of the MLSS represents a decrease in the bacterial population.

SLUDGE AGE

The sludge age is the amount of time, in days, that solids or bacteria are under aeration. Sludge age is used to maintain the proper amount of activated sludge in the aeration tanks. To calculate the sludge age, it is necessary to know the amount of suspended solids (pounds) that are in the aeration tank and the amount of suspended solids (pounds) that enter the aeration tanks daily.

To determine the pounds of suspended solids that are in the aeration tank; the pounds of mixed liquor suspended solids (MLSS) must be calculated. Therefore, the pounds of MLSS in the aeration tanks consists of the concentration (mg/l) of MLSS times the volume (MG) of the aeration tanks times the weight constant of 8.34 pounds per gallon of wastewater (Equation I.8).

$$\begin{aligned}&\text{pounds of suspended solids in the aeration tanks}\\&\quad=\text{MLSS (mg/l)}\times\text{volume of aeration tanks (MG)}\\&\qquad\times 8.34\,\text{pounds/gallon of wastewater}\end{aligned}\tag{I.8}$$

To determine the pounds of suspended solids that enter the aeration tank, the pounds of primary clarifier effluent (mixed liquor influent) suspended solids must

be calculated. Therefore, the pounds of primary clarifier effluent suspended solids consists of the concentration (mg/l) of primary clarifier effluent suspended solids times the flow (MGD) of the primary effluent times the weight constant of 8.34 pounds per gallon of wastewater (Equation I.9).

$$\begin{aligned}\text{pounds of suspended solids that enter the aeration tanks} \\ = \text{primary clarifier effluent suspended solids (mg/l)} \\ \times \text{flow of primary clarifier effluent (MG)} \\ \times 8.34\,\text{pounds/gallon of wastewater}\end{aligned} \tag{I.9}$$

The sludge age of an activated sludge process can be calculated by dividing the pounds of suspended solids or MLSS in the aeration tanks by the pounds of suspended solids that enter the aeration tanks (Equation I.10). The sludge age is Equation I.8 divided by Equation I.9.

$$\begin{aligned}\text{sludge age} = \text{suspended solids in the aeration tanks/} \\ \text{suspended solids entering the aeration tanks}\end{aligned} \tag{I.10}$$

SVI

The sludge volume index or SVI of an activated sludge process is used to measure the settling character (milliliters per gram) of the mixed liquor or activated sludge. The SVI is the volume of the mixed liquor suspended solids divided by the density of the mixed liquor suspended solids.

The volume of 1 l of mixed liquor suspended solids that settles after 30 minutes in a 1-l graduated cylinder typically is used to determine the SVI. The volume of settled solids (milliliters) is divided by the concentration of the mixed liquor suspended solids (g/l) to determine the SVI (Equation I.11). Because the definition of SVI requires milliliters per gram, milligrams must be converted to grams.

$$\begin{aligned}\text{SVI} = \text{volume of settled solids (ml) after 30 minutes/} \\ \text{concentration of mixed liquor suspended solids } (g/\text{l})\end{aligned} \tag{I.11}$$