# Problem of the Day
# 2014.Oct.12

## Discussion

As discussed in yesterday's Problem of the Day (2014.Oct.11), trickling filter math is fairly easy once you understand a few tricky aspects of the way the problems are done. Trickling filter math problems come in three general types:

1. Calculate the recirculation ratio
2. Calculate the hydraulic loading
3. Calculate the organic loading

The recirculation ratio was calculated in yesterday's Problem of the Day. The trick to remember with calculating the recirculation ratio is that **all units have to cancel as the recirculation ratio, r, is dimensionless**, meaning it has no units. Why wouldn't you want to use the railroad track, which is based on unit cancelation, doing a problem where all units have to cancel?

Today we are going to calculate the hydraulic loading to the same trickling filters described in yesterday's problem. **Hydraulic loading to trickling filters is always in units of gal/d•ft²** just like hydraulic loading, or surface overflow rate, is in clarifiers as discussed and demonstrated in the 09.Oct.2014 and 10.Oct. 2014 Problems of the Day.

**The trick in calculating the hydraulic loading to trickling filters is that both the influent flow and the recirculation flow are added together and then divided by the total surface area of the trickling filter(s)**:

$$H_L = \frac{Q + Q_r}{A}$$

where $H_L$ is the hydraulic loading, Q is the plant flow, $Q_r$ is the recirculation flow and A is the total trickling filter surface area. The reason this is important is because **when calculating the organic loading to a trickling filter, the BOD in the recirculation flow is NOT included**. Operators must keep this difference straight. The organic loading will be calculated tomorrow.

## Problem

Now for today's problem.

**Problem of the Day**: The Avon Valley WWTP has two biotowers each 105 feet in diameter with 25 feet of plastic, cross-flow media. The average daily flow to the plant is 8.3 MGD. There are two recirculation pumps each pumping 2,015 gpm of secondary effluent, with a BOD concentration of 18 mg/L, to the mix box upstream of the biotowers where it mixes with primary effluent. The average BOD concentration in the primary effluent is 125 mg/L. Calculate the hydraulic loading to these biotowers.

## Solution

Listing the information given in the problem statement, with appropriate units:

- Plant flow, Q = 8.3 Mgal/d
- Primary effluent BOD = 125 mg BOD/L
- Number = 2 TF (trickling filters)
- Diameter = 105 ft
- Media depth = 25 ft
- Secondary effluent BOD = 18 mg BOD/L
- Recirculation flow, $Q_r$ = 2 x 2,015 gal/min = 4,030 gal/min

The hydraulic loading is calculated using the equation above, repeated here:

$$H_L = \frac{Q + Q_r}{A}$$

where $H_L$ is the hydraulic loading, Q is the plant flow, $Q_r$ is the recirculation flow and A is the total trickling filter surface area. Keep in mind when calculating the **organic loading** to a trickling filter, the BOD in the recirculation flow is **not** included.

**Hydraulic loading to trickling filters is always in units of gal/d•ft$^2$**. Notice that in the current problem the plant flow is given in Mgal/d and the recirculation flow is given in gal/min. In order to add these flows together, they have to be in the same units, which obviously they are not. But what units do we want Q and $Q_r$ to be in? Because **hydraulic loading to trickling filters is always in units of gal/d•ft$^2$**, we want to convert both Mgal/d and gal/min to gal/d because those are the units needed, ultimately, in the answer. So we convert:

$$\left|\frac{Q\ \textbf{gal}}{\textbf{d}}\right| = \left|\frac{8.3\ \cancel{\text{Mgal}}}{\text{d}}\ \frac{10^6\ \text{gal}}{\cancel{\text{Mgal}}}\right| = \frac{8{,}300{,}000\ \textbf{gal}}{\textbf{d}}$$

and

$$\left|\frac{Q_r\ \textbf{gal}}{\textbf{d}}\right| = \left|\frac{4{,}030\ \text{gal}}{\cancel{\text{min}}}\ \frac{1{,}440\ \cancel{\text{min}}}{\text{d}}\right| = \frac{5{,}803{,}200\ \textbf{gal}}{\textbf{d}}$$

**Problem of the Day**: The Avon Valley WWTP has two biotowers each 105 feet in diameter with 25 feet of plastic, cross-flow media. The average daily flow to the plant is 8.3 MGD. There are two recirculation pumps each pumping 2,015 gpm of secondary effluent, with a BOD concentration of 18 mg/L, to the mix box upstream of the biotowers where it mixes with primary effluent. The average BOD concentration in the primary effluent is 125 mg/L. Calculate the hydraulic loading to these biotowers.

$$\left|\frac{H_L\ \textbf{gal}}{\textbf{d•ft}^2}\right| = \frac{Q + Q_r}{A} = \frac{(8{,}300{,}000 + 5{,}803{,}200)\ \textbf{gal}}{\textbf{d}}\ \frac{\cancel{\text{TF}}}{0.785\ \ 105\ \textbf{ft}\ \ 105\ \textbf{ft}\ \ 2\ \cancel{\text{TF}}}$$

The units in the railroad track are those required in the answer so the arithmetic completes the question:

(8,300,000 + 5,803,200) ÷ 0.785 ÷ 105 ÷ 105 ÷ 2 = <u>815 gal/d•ft$^2$</u>.

Good calculating and leave a comment so we know how we're doing!