Module 20:
Trickling Filters
Answer Key

Calculation

Capital City WWTF, which processes 2.0 MGD, is required to nitrify to meet the 2.0 mg/L ammonia discharge limit stated in their NPDES permit. A table reflecting average daily influent alkalinity and ammonia concentrations and the average daily ammonia removal requirement is presented in the table below.

	Alkalinity	Ammonia
	mg/L	mg/L
Influent	**415**	**52.0**
Final Effluent Requirement	***50***	***2.0***
Available for Nitrification	**365**	**---**
Removal Requirement	**---**	**50.0**

Determine how many pounds of alkalinity are available for nitrification, the pounds of ammonia removed and the pounds of alkalinity required for complete nitrification.

Flow (MG) x concentration (mg/L) x 8.34 = lbs

2.0 MGD x 365 mg/L alkalinity x 8.34 = **6,088 lbs alkalinity available for nitrification**

Now, determine how many pounds of alkalinity are required for nitrification. Hint: 7.2 lbs of alkalinity is required for every pound of ammonia-nitrogen oxidized.

	Alkalinity		Ammonia
	mg/L	lbs	mg/L
Influent	**415**	**---**	**52.0**
Final Effluent Requirement	**50**	**---**	**2.0**
Available for Nitrification	**365**	**6,088**	**---**
Removal Requirement	**---**	**--**	**50.0**

First, determine the pounds of ammonia removed:

2.0 MG x 50.0 mg/L ammonia removed (Influent conc. – effluent conc.) x 8.34 = **834 lbs ammonia removed**

834 lbs ammonia removed x 7.2 lbs alkalinity = **6,005 lbs of alkalinity are required**.

Based on this information, will the addition of alkalinity be required in order to achieve complete nitrification and if so how much?

6,088 lbs alkalinity available – 6,005 lbs alkalinity required = **83 lbs alkalinity in excess of requirement**

Answer: No.

☑ **Exercise:** Calculate the hydraulic loading of a Trickling Filter with the following data:

Diameter of TF	=	40 ft
Influent Flow	=	2.0 mgd

Ans: Surface Area = (π) x (radius)^2 = (3.14) x (20)^2 = 1,256 ft^2

$$\text{Hydraulic Loading} = \frac{(2{,}000{,}000\ \text{gpd})}{(1{,}256\ \text{ft}^2)} = \mathbf{1{,}592\ gpd/ft^2}$$

☑ **Exercise:** Calculate the organic loading of a Trickling Filter with the following data:

Diameter of TF	=	60 feet
Depth of Media	=	6 feet
Influent Flow	=	100,000 gpd
Influent BOD	=	200 mg/L

Ans: Media Volume (ft^3) = (π) x (radius)^2 x (depth) = (3.14) x (30 feet)^2 x (6 feet) = 16,956 ft^3

$$\text{Organic Load} = \frac{(200\ \text{mg/L}) \times (.1\ \text{mgd}) \times (8.34\ \text{lb/gallon}) \times (1{,}000\ \text{ft}^3)}{(16{,}956\ \text{ft}^3)} = \mathbf{10\ lb\ BOD/day/1{,}000\ ft^3}$$

☑ **<u>UNIT 1 EXERCISES:</u>**

1. Name the three components of a trickling filter.

Ans: Distribution System

Filter Media

Underdrain System

2. List the three functions of the underdrain system.

Ans: It has a sloped bottom which directs flow to a center channel

It provides support for the filter media, which sits on top of the underdrain system

It allows air circulation through the media

3. The slime layer or growth attached to the filter media is also known as **zoogleal film**.

4. The primary function of the bacteria and micro-organisms contained in the zoogleal film is to **reduce the carbonaceous BOD (cBOD) of the wastewater; however, they can also be utilized to reduce ammonia nitrogen through the process of "nitrification".**

5. Biological nitrification is the process in which **autotrophic** organisms convert ammonia into nitrate. ***Nitrosomonas*** bacteria oxidize ammonia to nitrite and ***Nitrobacter*** bacteria oxidize nitrite to nitrate.

6. Name the two general types of trickling filters based on method of distribution.

Ans: Circular trickling filter with rotary arms

Stationary trickling filter with spray heads

7. Describe the process and operation of a trickling filter.

Ans: Wastewater is distributed over the top of a filter media. Bacteria and micro-organisms attached to the filter media metabolize the organic substances in the wastewater, producing waste products such as carbon dioxide, ammonia, and phosphates. The treated wastewater is discharged, or pumped, to sedimentation tanks. A portion of the filter effluent may be re-circulated back to the trickling filter to improve removal efficiencies.

8. Increased influent flows lead to **increased** hydraulic loading which **decreases** detention time.

9. Identify the three classifications of trickling filters based on hydraulic and organic loading rates.

Ans: Standard Rate Trickling Filter

High Rate Trickling Filter

Roughing Trickling Filter

10. Sludge from the final clarifier should be pumped back to the **primary clarifier** or to a **sludge thickener** for further treatment.

11. Calculate the hydraulic loading rate of a trickling filter, given a diameter of 55 feet and an influent flow of 1.25 mgd.

Ans: Surface Area = $(\pi) \times (\text{radius})^2 = (3.14) \times (27.5 \text{ feet})^2 = 2{,}375 \text{ ft}^2$

$$\text{Hydraulic Loading (gpd/day/ft}^2\text{)} = \frac{\text{Influent Flow, gpd}}{(\text{Surface Area, ft}^2)}$$

$$= \frac{1{,}250{,}000 \text{ gpd}}{2{,}375\text{ft}^2} = 526 \text{ gpd/day/ft}^2$$

12. Calculate the organic loading rate of the trickling filter in the above question, given a media depth of 20 feet and an influent BOD of 235 mg/L.

Ans: Media Volume = $(\pi) \times (\text{radius})^2 \times (\text{depth}) = (3.14) \times (27.5 \text{ feet})^2 \times (20 \text{ feet}) = 47{,}493 \text{ ft}^3$

$$\text{Organic Load (lb BOD/day/1,000 ft}^3\text{)} = \frac{(\text{BOD, mg/L}) \times (\text{Flow, mgd}) \times (8.34 \text{ lbs/gallon}) \times (1{,}000 \text{ ft}^3)}{(\text{Volume, ft}^3)}$$

$$= \frac{(235 \text{ mg/l}) \times (1.250 \text{ mgd}) \times (8.34 \text{ lbs/gallon}) \times (1{,}000 \text{ ft}^3)}{47{,}493 \text{ ft3}}$$

$$= 51.6 \text{ lb BOD/day/1,000 ft}^3$$

Unit 2

☑ **Exercise:** Calculate the Ammonia Nitrogen removal efficiency of a Trickling Filter with the following data:

Influent NH_3-N = 10 mg/L

Effluent NH_3-N = 2.5 mg/L

Ans: [(10-2.5)/10] x 100 = 75%

UNIT 2 EXERCISES:

1. Identify five daily operations inspections appropriate for trickling filters.

Ans: Trickling filters should be inspected on a daily basis for signs of:

• Ponding • Uneven distribution of flow • Clogging	• Roughness or vibration • Leakage	• Filter flies • Unusual odors

2. List three abnormal operating conditions typically encountered in a trickling filter facility and explain what steps can be taken to correct each problem.

Ans: **Ponding**—Increase the recirculation rate to flush out solids. Slow the rotary distribution arm to flush out solids. As a last resort, chlorinate the filter media to kill excess biomass.

Odors—Pre-aerate the wastewater if the influent wastewater is the cause of odor. Increase the recirculation rate to flush out excessive solids from the filter media. Verify that the nozzles are allowing for equal distribution across the media surface.

Filter flies—Increase the recirculation rate to flush out the filter media. Temporarily and periodically flood the filter media. As a last resort, chlorinate the filter media to kill the filter flies.

Sloughing—Either increase or decrease the recirculation rate depending on the suspected cause of excessive sloughing: increase the rate if low organic loading or decrease the rate if high hydraulic loading. Divert a portion of the flow to additional treatment units to control the high hydraulic loading effect, if possible.

Weather conditions—Decrease the recirculation rate to maintain a warmer temperature. Remove orifices and end plates from the distributor arms to reduce the icing caused by spraying. Breakup any ice that forms on the filter media.

Shock loads—Increase the recirculation rate to dilute high organic loading. Operate multiple filters in series to limit the damage caused by high organic loading (organic loading should only affect the first filter and be harmless to the preceding ones). Operate multiple filters in parallel to reduce the high hydraulic loading.

3. Give one example of an operation modification that may be required due to sampling results.

Ans: **High Total Suspended Solids**—Adjust the hydraulic loading rates as necessary. Excessive flow through the filter can flush out solids and cause high TSS.

High Biochemical Oxygen Demand—Develop and implement sewer-use ordinances to establish limitations on organic loading discharges.

High Settleable Solids—Adjust the hydraulic loading rate as necessary. Calculate the organic loading rate to determine if the rate is acceptable: increase recirculation to dilute the organic loading, place additional trickling filters units in service to distribute the excessive organic loading.

Low Dissolved Oxygen—Check for filter media clogging. Calculate the organic loading rate to determine if the rate is acceptable: increase recirculation to dilute organic loading, place additional trickling filters units in service to distribute excessive organic loads.

High Chlorine Demand—Survey sewer system customers to determine the source, it is most likely a non-domestic type wastewater discharge.

Poor Clarity—Adjust the hydraulic loading rate as necessary to control high settleable solids.

Low or High pH—Survey sewer system customers to determine the source, it is most likely a non-domestic type wastewater discharge. Adjust the pH with sodium hydroxide (to increase pH).

High Fecal Coliform—Increase solids and/or sludge disposal operations to remove the excessive solids.

Nutrient Imbalance—Adjust the number of upstream treatment units (i.e. primary clarifiers) to better control the treatment efficiency and nutrient loadings. Add necessary nutrients, if deficiency is the cause.

☑ **<u>Unit 3 Exercises:</u>**

1. List five items that should be inspected after new construction of a trickling filter and before start-up of the operation.

Ans:	• Packing grease	• Underdrain System
	• Nozzles	• Painted Surfaces
	• Media	• Valves
	• Distributor Arm	• Manuals

2. Describe the process of putting a filter into operation with no growth on the media.

Ans: After checking all components, begin operation of the unit. Allow several weeks for the bio-growth to develop. High rate recirculation will help to establish growth. Attempt to equalize flow in upstream processes so that high hydraulic peak loadings are minimized. Maintain a low sludge blanket level in the upstream primary clarifier so that organic loading to the trickling filter is minimized as much as possible. Notify regulatory agencies that effluent quality may not be in compliance with the NPDES Permit until the bio-growth is established.

3. List and describe five normal maintenance tasks required for trickling filters.

Ans: **Bearings and Seals**—Both distributor bearings should be lubricated as per the manufacturer's recommendations. Check the manufacturer's recommendations and change the oil accordingly. Replace the mercury seals as needed.

Distributor Arms—Use a carpenter level to check the vertical alignment of the center column and the distributor arms. Check for the proper tension of the horizontal and vertical guy supports between the column and arms. Clean the nozzles when they become clogged. Flush out each distributor arm at least once a month. Major variations in vertical alignment should be corrected.

Fixed Nozzles—Conduct a pan test annually to determine if all nozzles are providing equal flow. Flush out internal piping to prevent solids accumulation, especially at the end of the manifold nozzles.

Underdrains—Check annually for any accumulation of solids or debris. Visually inspect underdrains using a flashlight, mirror, or robotic sewer TV camera on an annual basis.

Pumps and Level/Recirculation Control System—Verify level control system set points on a quarterly basis. Test all low level and high level alarms on a quarterly basis. Follow any additional manufacturer's recommendations.