Module 18:

The Activated Sludge Process - Part IV

Answer Key

Unit 1 Review Exercise

1. List the five types of nitrogen.

Ans: Ammonium, Ammonia, Nitrite, Nitrate and Organic-N.

2. List seven nitrogen removal mechanisms.

Ans: Biological nitrification, biological denitrification, living systems, land application, ammonia stripping, breakpoint chlorination and ion exchange.

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.

Climates with large temperature variations can have a significant impact on denitrification. For example, the denitrification reactor volume at 10 °C would be about four times the volume required at 20 °C to achieve the same degree of nitrification. Why do you think this is the case?

Ans: T1 = 20 degrees C
T2 = 10 degrees C

$P = 0.25T^2$

$$\frac{P2}{P1} = \frac{0.25(T2)^2}{0.25(T1)^2} = \frac{0.25(10)^2}{0.25(20)^2} = \frac{25}{100} = 1/4$$

The denitrification rate at 10 degrees C is only 1/4 the rate at 20 degrees C and would, therefore, require 4 times the reactor volume to achieve the same degree of treatment.

Exercise for Unit 1 – Nitrification and Denitrification

1. MCRT is the abbreviation for Mean Cell Residence Time .

2. The two types of aeration systems used in nitrification processes are surface aerators and diffusers.

3. The optimal pH range for biological nitrification is 7.8 to 8.2 .

4. Nitrification in the winter months may require up to five times the detention time used during the summer.

   a. True b. False

5. Single stage biological nitrification typically requires a MCRT of 8 to 20 days.

6. For biological nitrification to proceed efficiently, there must be an adequate supply of carbon, nitrogen, and phosphorous in the wastewater. If the phosphorus level is too low, it may be remedied by adding a phosphate fertilizer to the aeration tank.

   a. True b. False

7. In a denitrification process, it may be necessary to add a carbon source such as methanol if the total effluent nitrogen limit is less than 7.5 mg/L.

8. List the four types of suspended growth biological nitrification reactors that are commonly used.

   a. conventional or plug flow .

   b. complete mix .

   c. extended aeration .

   d. SBR .

9. Given the following data, determine how many pounds of alkalinity are available for nitrification, the pounds of ammonia removed and the pounds of alkalinity required for nitrification. Based on this information, is there adequate alkalinity to achieve complete nitrification?

   Influent flow = 1.5 MGD
   Influent ammonia nitrogen = 40 mg/L
   Effluent ammonia nitrogen = 2 mg/L

Alkalinity available for nitrification = 160 mg/L

Pounds of alkalinity available for nitrification:

1.5 MG X 160 mg/L X 8.34 = 2001.6 lbs of alkalinity available for nitrification

Pounds of ammonia removed:

1.5 MG X 38 mg/L X 8.34 = 475.38 lbs of ammonia removed

Pounds of alkalinity required for nitrification:

475.38 lbs of ammonia removed X 7.2 lbs of alkalinity = 3422.736 lbs of alkalinity required for complete nitrification

3,423 lbs alkalinity needed – 2,002 lbs alkalinity available = 1,421 lbs alkalinity needed.

Answer: No. At least 1,421 lbs of alkalinity will need to be added.

Exercise for Unit 2 – Biological Phosphorus Removal

1. List the three forms of phosphorus considered important for wastewater.
   a. Orthophosphates
   b. Polyphosphate (P_2O_7)
   c. Organically Bound Phosphorus

2. List four metal salts that can be used in treating water for phosphorus removal.
   a. Aluminum sulfate (or alum)
   b. Ferric chloride
   c. Ferric sulfate
   d. Ferrous sulfate

3. Using lime to remove phosphorus requires that the wastewater has a pH of about 11. After pH removal, carbon dioxide gas can be injected into the water to lower the pH.

4. How do the three phosphorus removal mechanisms differ?

Potential responses:

The A/O process is a "mainstream" process where phosphorus is removed along the main plant flow stream (i.e., the secondary clarifier). The PhoStrip process removes phosphorus in a "sidestream" process (i.e., in the sidestream anaerobic stripper tank).

The A/O and PhoStrip processes are biological, whereas the flocculation and precipitation processes are chemical.

The anaerobic and aerobic hydraulic retention times (HRT) for the PhoStrip process is longer than the corresponding HRTs for the A/O process.

Unit 3

Explain the difference between the A^2O process and the Bardenpho process.

Ans: The A2O process is a three stage process consisting of an anaerobic stage, an anoxic stage and an aerobic stage. The Bardenpho process is a five stage process consisting of an anaerobic stage, then an anoxic stage, followed by an aerobic stage and then another anoxic and aerobic stage.

Exercise for Unit 3 - Combined Nitrogen and Phosphorus Removal or Biological Nutrient Removal (BNR)

1. In the spaces below, write in the typical range of values for the indicated process control parameters:

a. MCRT	A^2O	4 – 27 days	Bardenpho	10 – 40 days
b. RAS recycle rate	A^2O	20 – 50 %	Bardenpho	50 – 100 %
c. MLSS concentration	A^2O	3000 – 5000 mg/L	Bardenpho	2000 – 4000 mg/L
d. F/M ratio	A^2O	0.15-0.25 lb BOD / lbMLSSday		
	Bardenpho	0.1-0.2 lb BOD / lbMLSSday		

2. From the chart in Figure 3.3, determine the optimum pH range for the following processes:

a. Aerobic treatment 6.5 – 8.3

b. optimum for nitrifiers 7.5 – 8.2

c. phosphorus removal by Al^{3+} addition 5.0 – 6.5

d. phosphorus removal by Fe^{3+} addition 4.0 – 6.0