

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.



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

$$P = 0.25T^2$$

$$\frac{P_2}{P_1} = \frac{0.25(T_2)^2}{0.25(T_1)^2} = \frac{0.25(10)^2}{0.25(20)^2} = \frac{25}{100} = 1/4$$

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 7.2 to 9.0.
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



Exercise for Unit 2 – Biological Phosphorus Removal

1. List the three forms of phosphorus considered important for wastewater.
 - a. Orthophosphates
 - b. Polyphosphate (P₂O₇)
 - 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 A²O 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 ² O | <u>4 – 27 days</u> | Bardenpho | <u>10 – 40 days</u> |
| b. RAS recycle rate | A ² O | <u>20 – 50 %</u> | Bardenpho | <u>50 – 100 %</u> |
| c. MLSS concentration | A ² O | <u>3000 – 5000 mg/L</u> | Bardenpho | <u>2000 – 4000 mg/L</u> |
| d. F/M ratio | A ² O | <u>0.15-0.25 lb BOD / lbMLSSday</u> | | |
| | Bardenpho | <u>0.1-0.2 lb BOD / lbMLSSday</u> | | |

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

- | | |
|--|------------------|
| a. Aerobic treatment | <u>6.5 – 8.3</u> |
| b. optimum for nitrifiers | <u>7.5 – 8.2</u> |
| c. phosphorus removal by Al ³⁺ addition | <u>5.0 – 6.5</u> |
| d. phosphorus removal by Fe ³⁺ addition | <u>4.0 – 6.0</u> |