Module 8:
Overview of Advanced Wastewater Treatment Processes
Answer Key

Exercise for Unit 1 – Odor Control

1. Describe some of the maintenance schedules used at your treatment plant:

Ans: For headworks: is there a chemical addition schedule; is aeration employed routinely?

For primary clarifiers: are chemicals or air added routinely; are sludge levels checked routinely; are tanks covered?

For anaerobic digesters: is the cover seal checked routinely; is the tank checked for leaks; is the gas burner status automatically checked?

For disinfection systems: is the operation of the chlorinator checked routinely; is the dosage matched to the plant effluent flow rate; is the system checked routinely for leaks; is sludge removed routinely from the contact chamber?

Exercises for Unit 2 – Effluent Polishing

Exercise

1. What is the importance of mixing in the coagulation process?

Ans: Vigorous mixing during coagulation is important to ensure that the coagulants are thoroughly mixed into the waste stream and that the solids particles make physical contact with each other.

2. What is flocculation?

Ans: Flocculation is the actual gathering together of smaller suspended particles into flocs, thus forming a readily settleable mass.

3. Briefly describe the jar test procedure.

Ans: Various types of chemicals or different doses of a single chemical are added to sample portions of wastewater in a jar test unit and all portions of the samples are rapidly mixed. After rapid mixing, the samples are slowly mixed to approximate the conditions in the plant. Mixing is stopped and the floc formed is allowed to settle. The appearance of the floc, the time required to form a floc, and the settling conditions are recorded. The supernatant is analyzed for turbidity, suspended solids, and pH. With this information the operator selects the best chemistry or best dosage to feed on the basis of clarity of effluent and minimum cost of chemicals.

Exercise – Gravity Filtration

1. When should a gravity filter be cleaned?

Ans: A gravity filter should be cleaned when the solids capacity of the media has nearly been reached but before solids break through into the effluent.

2. How is head loss through the filter media determined?

Ans: The head loss through the filter media is determined by measuring the water pressure above and below the filter media. When water flows through the media, the pressure below the media will be less than the pressure above the media (when the pressure levels are measured or read at the same elevation). The difference between the two readings is the head loss.

3. What can happen if the filter media is not thoroughly cleaned during each backwashing?

Ans: If the filter media is not thoroughly cleaned during each backwashing, a buildup of solids will occur. The end result of incomplete cleaning is the formation of mudballs within the bed.

Exercise – Pressure Filtration

1. List the major components of a pressure filter system.

Ans: The major components of a pressure filter system include: a holding tank or wet well; filter feed pumps; chemical coagulant feed pump system; filters; filter backwash wet well; filter backwash pumps; and decant tank.

2. What is the purpose of the holding tank located just ahead of a pressure filter?

Ans: The purpose of the holding tank is to store water and to allow additional settling of the suspended solids before the water is applied to the filter.

3. What could cause high operating filter differential pressures?

Ans: High operating differential pressures could occur if either (1) the media is filled with suspended material; and/or (2) excessive chemical feed is blinding the media.

Exercise - Continuous Backwash, Upflow, Deep-Bed Granular Media Filtration

1. What happens if the air lift is allowed to operate without wastewater flowing to the filter?

Ans: Dirty sand will be carried to the top of the filter and deposited at the top of the sand bed. This dirty sand will slough off solids into the filter effluent when the filter is restarted for normal operation.

2. What are the advantages of continuous backwash, upflow, deep-bed silica sand media filters over other types of granular media filters?

Ans: They do not need to be shut down to clean the filter media; consequently they can be run continuously. Therefore, they can provide the same filtration capacity using fewer or smaller filter systems. Also, they provide excellent quality effluent with very low turbidity because of the deep-bed media design.

3. How is silica sand media cleaned in a continuous backwash, upflow, deep-bed silica sand media filter?

Ans: Dirty sand is carried to the top of the filter by an air lift pump. Sand and dirty water are separated there and the dirty sand falls through a baffled launder where it is contacted with upflowing filtered water. This water helps to clean the sand as it passes through the launder and it carries the sloughed solids to the reject compartment where they are discharged over a weir. The clean sand falls out of the launder onto the top of the sand bed, replenishing the sand bed with clean sand.

Exercise - Cross Flow Membrane Filtration

1. How do cross flow filtration processes differ from conventional filtration?

Ans: In cross flow filtration, wastewater flows across the surface of a membrane rather than through a bed of granular media. The membrane permits water to pass through but blocks the passage of particles. Other differences include the length of the filter run and the ease of cleaning the membranes.

2. The amount of flux across a membrane is dependent on what factors?

Ans: The amount of flux across a membrane is dependent upon transmembrane pressure (driving force), flow rate across the membrane surface (turbulence on the membrane), concentration of waste material, temperature, viscosity and cleanliness of the membrane surface.

3. List the steps for cleaning (washing) a membrane.

Ans: The steps are as follows:

1. Displacement of waste from the system with water.
2. Washing the membranes with a caustic and surfactant to remove oils and grease.
3. Flushing the surfactant from the membrane with warm water.
4. Washing the membrane with an acid cleaner to remove salt buildup.
5. Flushing the acid from the membrane with warm water.
6. Recording clean water flux as a check on cleaning effectiveness.

Review Questions for Unit 3 – Phosphorus Removal

REVIEW QUESTIONS:

1. What is the luxury uptake of phosphorus?

Ans: It is a microbiological process in which the wastewater environment is manipulated to encourage the microorganisms to absorb more phosphorus into their cell mass then they would normally absorb.

2. The phosphorus stripping process using luxury uptake is similar to an activated sludge plant with the exception of what tanks?

Ans: Anaerobic selector tank

3. Why is it important to closely control the detention time in the anaerobic phosphorus stripping tank?

Ans: Because if the microorganisms are kept in the tank too long, they will die. If they are not kept in there long enough, they will not be forced to release phosphorus from their cell mass.

REVIEW QUESTIONS:

1. What is a typical pH range for operation of a lime precipitation system for phosphorus removal?

Ans: pH of 10 to 11

2. Why would you perform a jar test when removing phosphorus by the lime precipitation process?

Ans: Jar tests can be used to determine what pH levels and polymer dosages form the largest floc possible and allow the fastest settling of the floc formed.

3. When removing phosphorus by the lime precipitation process, the phosphorus concentration normally does not control the lime dosage required, what does?

Ans: The amount of alkalinity present controls the lime dosage.

Exercise for Unit 3 – Phosphorous Removal

1. How would you determine the optimum alum dosage for phosphorus removal?

Ans: Conduct a jar test to find the dosage that produces the best clarification with the least amount of alum. Confirm the removal by testing the supernatant for phosphorus.

2. What would you do first if you observed a cloudy appearance in the effluent from a filtration unit in a phosphorus removal system that uses alum?

Ans: Check to make sure that the alum feed system is not overdosing because the cloudy condition of the effluent is indicative of an alum overdose.

3. What safety hazard might operators encounter in areas where aluminum sulfate is mixed with water?

Ans: Slippery surfaces, especially slippery floors.

4. Two chemical processes are commonly used to remove phosphorus from wastewater are __lime__ precipitation and __alum__ flocculation and precipitation.

5. A polymer is often used as a flocculation aid with alum, because the aluminum phosphate precipitate is not dense enough to provide adequate removal.
   a. _X_ True b. ____ False

6. Luxury uptake is a term used to describe a reaction of microorganisms after they have been depleted of phosphorous.

7. Aerobic is a condition in which atmospheric or dissolved molecular _oxygen_ is present in the aquatic environment.

8. A strict anaerobic environment is necessary in the anaerobic selector to force the microorganisms to utilize the polyphosphates in their cell mass for energy to survive their stay in the anaerobic selector.
   a. _X_ True b. ____ False

9. Typically, the pH of the wastewater will be raised to the range of _10_ to _11_ with the addition of lime to properly precipitate the phosphorus present.

10. When alum is mixed with wastewater, it acts as an acid, reducing the pH of the wastewater (by reducing alkalinity). Optimum phosphorus removal is generally achieved at a pH range of approximately _6.0_ to _7.0_.

11. _pH_ testing is recommended to optimize the alum dosage and to avoid overdosing.

Exercises for Unit 4 – Nitrogen Removal

Exercise

1. Nitrification can be accomplished by the use of what two types of biological growth reactors?

Ans: Nitrification can be accomplished by using suspended growth reactors or attached growth reactors.

2. What can an operator do to maintain sufficient alkalinity in a nitrification process?

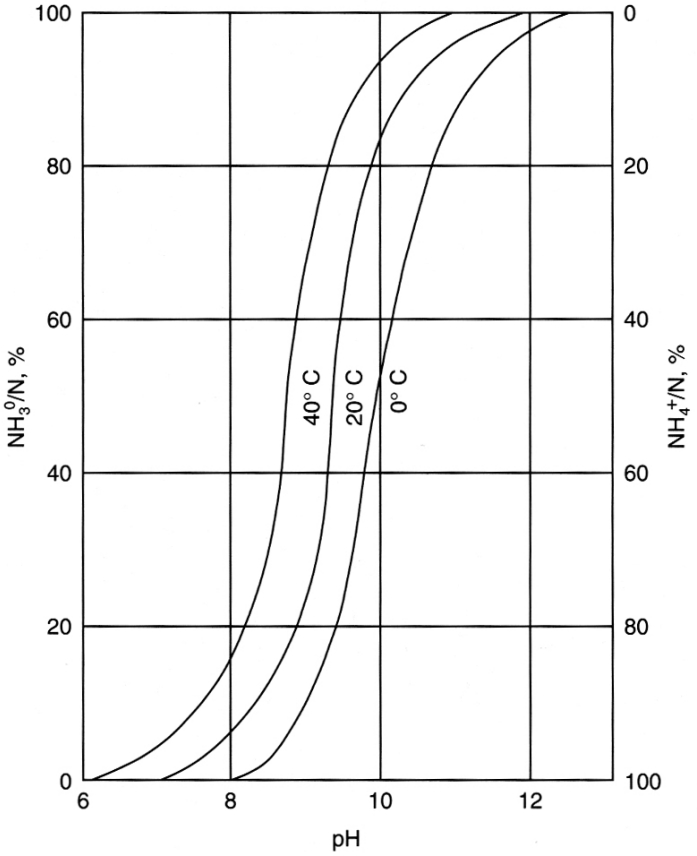
Ans: Sufficient alkalinity can be maintained in a nitrification process by adding calcium oxide (lime) or soda ash.

3. What tests must be conducted to monitor nitrogen levels in the reactors during the nitrification process?

Ans: Nitrogen tests that must be performed at various key points along the reactors during the nitrification process include ammonium (NH_4^+), nitrite (NO_2^-) and nitrate (NO_3^-). A predominance of ammonia indicates inadequate nitrification. A predominance of nitrite indicates incomplete nitrification. A predominance of nitrate, with essentially no ammonia, indicates successful nitrification.

Exercise

Using the figure below answer the following three problems:



Effects of pH and temperature on equilibrium between ammonium ion and ammonia gas [9]

1. At a temperature of 0°C and a pH of 11.0, what are the approximate percentages of ammonia gas and ammonium ion in solution?

Ans: 90% ammonia gas, 10% ammonium ion.

2. At a pH of 9.0 and a temperature of 20°C, what are the approximate percentages of ammonia gas and ammonium ion in solution?

Ans: 30% ammonia gas, 70% ammonium ion.

3. If the wastewater contains 60% ammonia gas and 40% ammonium ion, and the temperature of the wastewater is 40°C, what would be the approximate pH of the wastewater?

Ans: 8.7 to 9.0

Exercise

1. Why must the pH of the wastewater be increased to successfully strip ammonia from wastewater?

Ans: Because ammonia is present in the wastewater in equilibrium with ammonium ion and at alkaline pHs (9 and higher) most of the nitrogen will be present in the ammonia form. Ammonia is a gas that can be stripped from the wastewater.

2. What are the two most common operating problems for ammonia strippers?

Ans: Freezing and scaling.

3. How is scale (calcium carbonate) formed during the stripping process?

Ans: Lime (calcium oxide) is often used to increase the pH during ammonia stripping. When carbon dioxide from the atmosphere reacts with calcium in alkaline environment, calcium carbonate (scale) is formed. The scale coats the surfaces of the equipment it comes in contact with.

Exercise

1. Explain how the breakpoint chlorination process works.

Ans: By adding sufficient quantities of chlorine to wastewater containing ammonia nitrogen, the complete oxidation of the ammonia nitrogen takes place at a level of chlorine addition normally referred to as the “breakpoint”.

2. What is the appropriate application for breakpoint chlorination?

Ans: Secondary or filtered effluent is the appropriate application for breakpoint chlorination. Breakpoint chlorination also is frequently used as final cleanup following other nitrogen removal processes.