Wastewater Treatment Plant Operator Certification Training

Module 19: Treatment Ponds and Lagoons

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The Pennsylvania State Association of Township Supervisors (PSATS)
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Topical Outline

Unit 3 – Typical Operating Problems

1. Poor Effluent Quality
   - A. Aeration Equipment Failure
   - B. Organic Overload
   - C. High Total Suspended Solids (TSS)
   - D. Light Blockage
   - E. Toxic Influent Material
   - F. Loss of Pond Volume
   - G. Short Circuiting
2. Low Dissolved Oxygen
   - A. Low Algae Growth
   - B. Excessive Scum Accumulation
   - C. Aeration Problems
   - D. Organic Overload
   - E. Short Circuiting
3. Odors
   - A. Anaerobic Conditions
   - B. Hydrogen Sulfide
4. Falling Liquid Levels
   - A. Leakage of Levees
   - B. Discharge Valve Open
   - C. Plugged Inlet Lines
5. Animal Burrows
   - A. Structural Failures Due to Burrowing
   - B. Removal Techniques
6. Excessive Vegetation
   - A. Emergent Weeds
   - B. Suspended Vegetation
   - C. Dike Vegetation

Unit 1 – General Overview

Learning Objectives

- Describe why ponds are used in wastewater treatment.
- Identify three (3) types of ponds.
- Discuss the advantages and disadvantages of using ponds for treatment.
- Name two levels of treatment that ponds are capable of achieving.
- Discuss why ponds have long detention times and large volumes.

Historical Uses

Ponds and lagoons have been used for hundreds of years and for a variety of purposes. In ancient times, organic wastes were intentionally added to ponds to stimulate the growth of algae, which acted as a food supply to increase fish populations for harvesting.[1]

Initially, the first wastewater collection systems simply discharged wastes into the nearest body of water.

The volume of wastewater increased as populations increased, and clean water bodies were negatively impacted. The need to isolate wastewater from other water sources became apparent. Therefore, treatment ponds were created to protect clean water sources by separating wastewater.

List some undesired effects of discharging wastewater directly into clean water sources.

Types of Ponds

The terms, *treatment ponds* and *treatment lagoons*, are used interchangeably. For our purposes, we will generally use the term, "pond." There are three basic classifications, or types, of ponds utilized for wastewater treatment. These include aerobic, anaerobic, and facultative ponds.[2]

Aerobic Ponds contain dissolved oxygen (DO) throughout the entire depth of the pond all the time. Treatment is accomplished through the stabilization of organic wastes by aerobic bacteria and algae.

Dissolved oxygen can be introduced into a pond through several means.

- **Algae**, like other plants, emit dissolved oxygen as a by-product of photosynthesis..
- **Wind**, blowing across the surface of a pond, will cause oxygen to be absorbed into the water.
- **Mechanical aeration** devices agitate the water surface to cause spray and waves so that oxygen can be absorbed from the air. Some mechanical devices include paddle wheels, mixers, and rotating brushes.
- **Diffused aeration** utilizes a blower system to discharge air into the water. The air stream is broken into fine bubbles; the smaller the bubbles, the greater the oxygen transfer. (NOTE: The Activated Sludge modules of DEP Wastewater Treatment Plant Operating Training explain aeration methodology in further detail.)

Notice in the chart below how the source of dissolved oxygen is related to the depth of the treatment pond.[3,4]

Source of DO	Typical Depth of Pond
Algae Growth	1-2 feet
Wind-aided Surface Aeration	1-2 feet
Mechanical Agitation and Surface Mixers	6-20 feet
Air Diffusers	6-20 feet

An aerobic pond with no mechanical agitation should be shallow. Why is this important?

Anaerobic Ponds function without dissolved oxygen (DO) throughout any of its depth. Treatment is accomplished by anaerobic bacteria at the bottom of the pond, which ferment the sludge.

Anaerobic ponds have a depth of eight (8) to twenty (20) feet, and a typical detention time of 20 to 50 days. These ponds are ideal for pretreating strong industrial wastewater, such as that from food processing functions.

A deep sludge blanket covers the bottom of these ponds, while a scum layer covers the surface. The scum layer is important to the pond because:

- It helps to minimize offensive odors
- It blocks transfer of DO through surface contact
- It helps insulate the pond or lagoon to ensure ideal conditions for sludge fermentation.

Facultative Ponds contain a supernatant (upper) layer that is aerobic, and lower layers that are anaerobic.

Facultative ponds typically range from three (3) to eight (8) feet in depth.[5] The detention time can be as short as 25 days or as long as 180 days.[6] The primary operational problem with facultative ponds is that the presence of algae in the effluent results in high total suspended solids.

Using the information you already know about aerobic and anaerobic ponds, apply your critical thinking skills to the following questions about facultative ponds:

- What supplies the dissolved oxygen (DO) for the supernatant layer of the facultative pond?

- What stabilizes organic waste in the supernatant layer of the facultative pond?

- What ferments the organic waste in the anaerobic layer of the facultative pond?

- Why is the facultative pond the most common type of treatment pond?

Advantages of Ponds

Compared to conventional treatment processes, ponds and lagoons offer many advantages for smaller installations. Treatment ponds and lagoons:

- Are economical to operate
- Are capable of handling high flows
- Are adaptable to changing loads
- Accumulate sludge at a rate of 0.2 lbs per lb of BOD removed is much lower than conventional facilities where the accumulation rate is anywhere from 0.5 lbs to 1.0 lbs of solids per lb of BOD removed.
- Have an increased potential design life
- Serve as wildlife habitat
- Consume little energy.

Disadvantages of Ponds

There are a few disadvantages to ponds and lagoons. The facilities:

- May cause odors
- Require large land areas
- Are affected by climactic conditions
- May have high suspended solids levels in effluent
- Might contaminate groundwater.
- Do not have the daily sludge wasting that a conventional system has. After 5 - 10 years of operation sludge has built up and needs removed. Lagoon operators should put aside a portion of their budget each year for sludge removal, even though actual removal may be only once every 5 years. Removal of sludge from a lagoon requires quite a bit of time and labor, especially when compared to a conventional system

Pond Design and Performance Overview

Orientation

Treatment ponds and lagoons can be oriented in two ways.

Series Ponds contain two or more ponds (also called cells) that are connected, with one directly following the next. Different types of ponds are often operated in a series. For example, a facultative pond may be followed in the series by an aerobic pond. Series ponds eliminate the possibility of short-circuiting.

Parallel Ponds contain two or more ponds (also called cells) that are operated side by side. One pond can be removed from service without disruption of treatment in the other pond(s).

For the most efficient operation, the DEP's *Facilities Manual* recommends that an optimal system should contain at least three cells and should be designed to operate in series *and* parallel.[7]

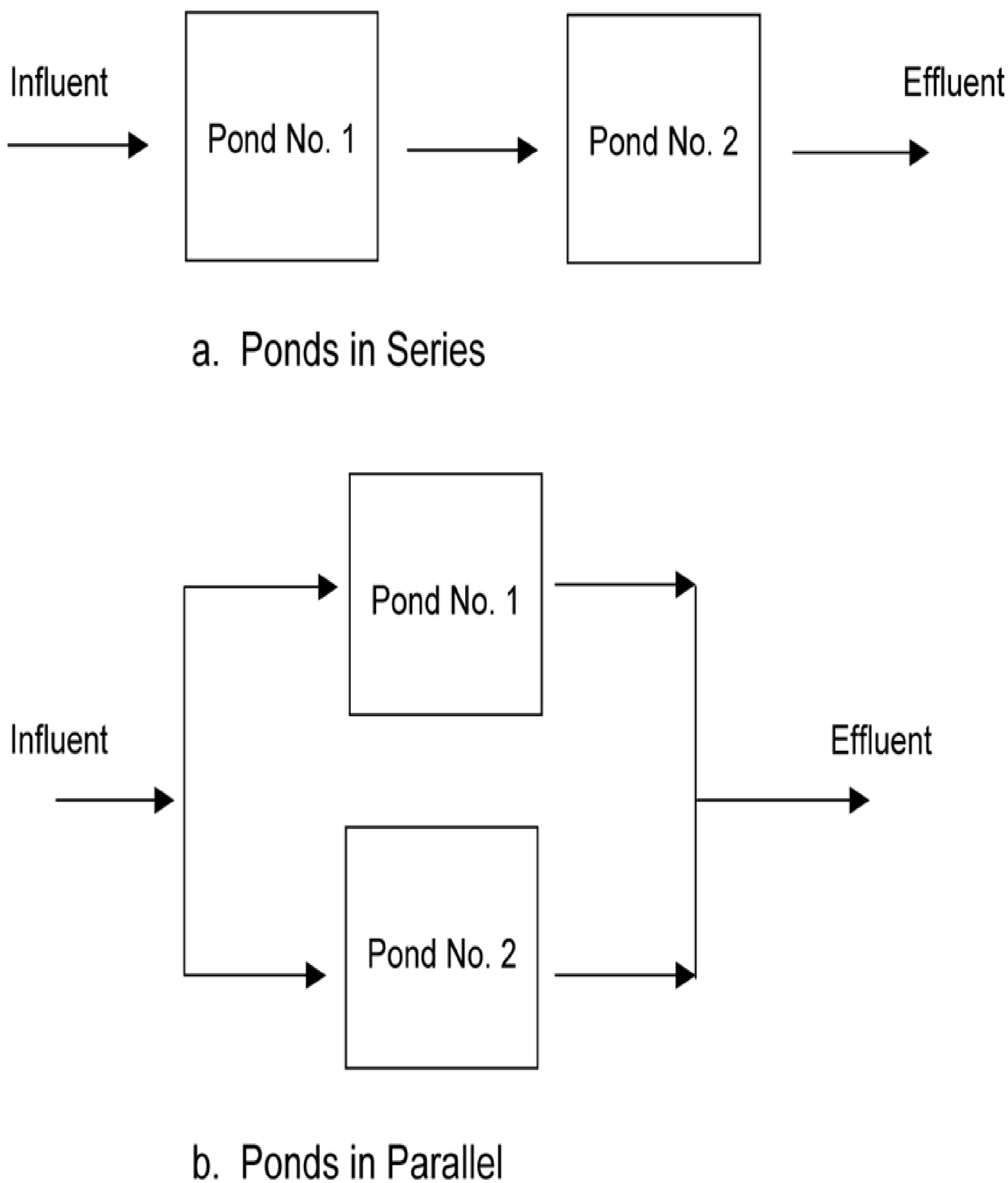

Figure 1.1 Orientations of Ponds

Treatment Uses

Ponds and lagoons are used for a variety of treatments.

In an **Oxidation Pond**, wastewater enters the treatment pond after it has received primary treatment, i.e., clarification. When utilized, oxidation ponds become the primary biological treatment process.

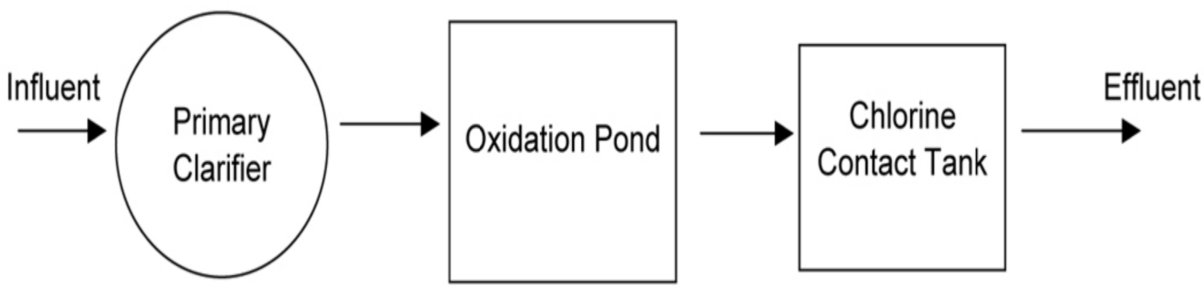

Figure 1.2 Oxidation Pond

A **Polishing Pond** is operated after the secondary treatment, i.e., a trickling filter. Polishing Ponds are sometimes referred to as Tertiary Ponds.

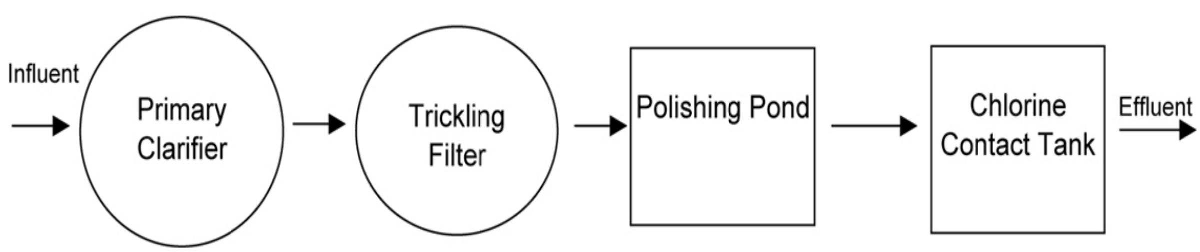

Figure 1.3 Polishing Pond

Potential Treatment Efficiencies

Potential treatment efficiencies of a facultative pond depend upon many factors.[8] These factors include:

- Biochemical Oxygen Demand (BOD) (further discussed in Unit 2)
  - Typically designed to reduce to approximately 30 mg/l.
  - Performance ranges are 30 to 40 mg/l.

- Total Suspended Solids (TSS)
  - Typical performance ranges are from 40 to 100 mg/l.
  - The higher values are found in warmer weather during high algae growth periods.

- Coliform Bacteria
  - Bacteria and viruses are removed by sedimentation, predation, natural die-off, and adsorption.

- Nutrients
  - Between 10% and 25% of ammonia nitrogen is removed.
  - Less than 40% of phosphorus is removed.

To determine the percent removal in a pond, use this formula:

$$\text{Percent Removal (\%)} = \frac{\text{(Influent Concentration, mg/l)} - \text{(Effluent Concentration, mg/l)}}{\text{(Influent Concentration, mg/l)}} \times 100$$

Try this example as a class: Influent Ammonia Nitrogen = 25 mg/l
Effluent Ammonia Nitrogen = 20 mg/l
What is the percent removal?

Naturally Occurring Processes

Several natural processes occur simultaneously throughout the strata of a pond. Different forms of bacteria and algae are found in a pond; they use soluble substances as food by absorbing it through their membranes. When a pond or lagoon is operating properly, a natural cycle is created in which one organism's waste products are utilized by another organism for sustenance.

Remember that the two layers, or strata, of a facultative pond are the aerobic zone and the anaerobic zone. While most processes within the two strata work independently of one another, there is complex interaction between these two separate communities. The exchange of soluble organic matter and nutrients connects them.

Aerobic Zone

In the aerobic zone, algae utilize sunlight, carbon dioxide, nutrients, and ammonia. Algae emit dissolved oxygen as a by-product of this process. The dead algae cells then become part of the organic food matter of the ecosystem.

The aerobic bacteria utilize oxygen and influent organic matter. They emit carbon dioxide, nutrients, and ammonia. The dead bacteria cells become part of the organic food matter of the ecosystem.

Anaerobic Zone

In the anaerobic zone, bacteria utilize influent organic matter. They emit water, carbon dioxide, nutrients, ammonia, alkalinity, hydrogen sulfide, and methane as waste products. The bacteria create organic acids. The dead bacteria cells become part of the organic food matter of the ecosystem.

See Figure 1.5 in your workbook to see the processes that occur in each zone.

Because a pond system's treatment of wastes is through natural processes seasonal and even diurnal differences (day verses night) can and will affect microbial photosynthesis and respiration, water temperature and water movement which can produce significant swings in effluent characteristics including DO and pH levels. Although low DO is most common early in the morning, it can occur at any time. The most common causes in ponds are cloudy weather, death of an algal bloom, and pond turnover. Cloudy, overcast skies decrease the amount of light reaching the surface of the pond, which results in decreased photosynthetic activity and poor oxygen production. Algae can die at any time; however, a common cause of algal mortality is chemical treatment. After an algae die-off, pond water changes color, usually from green to brown. Concurrent with the decrease in DO, the total ammonia nitrogen increases and the pH decreases. The bloom will generally return naturally within a week or so; however, the pond should be monitored closely during the transitional period and aerated as necessary. Pond turnover is most common in deep ponds (>6 ft) and involves a phenomenon referred to as stratification. Water at the bottom of the pond cools down, and a temperature gradient, called the thermocline, develops between warm surface water and cool bottom water. The thermocline acts as a physical barrier between the surface water (epilimnion) and bottom water (hypolimnion). Because photosynthesis, and hence oxygen production, occurs at the surface, the hypolimnion becomes hypoxic and develops a biologic oxygen demand. When the pond is mixed, or “turns over,” the oxygen is removed as the biologic oxygen demand of the hypolimnion is satisfied. This sudden removal of oxygen can result in oxygen depletion. The most common cause of pond turnover in the southern USA is a summer thunderstorm, in which energy released from wind and wave action is sufficient to mix the pond. Pond turnover can result in catastrophic oxygen depletion and, once a pond has stratified, turnover can be caused by seining, aeration, or other management practices that result in mixing of the epilimnion and hypolimnion. Pond turnover can be avoided by performing a weekly oxygen profile during periods of greatest risk. The thermocline can be detected by the sudden change in DO and water temperature that occur there. Its development can be safely disrupted by aeration if there has not been enough time for a biologic oxygen demand to develop in the hypolimnion. If the hypolimnion, identified by low DO and temperature readings, is limited to a foot off the bottom, aeration should be safe. Because of the time required to perform chemical oxygen tests (the Winkler method requires ~10 min), use of an electronic oxygen meter is strongly recommended.

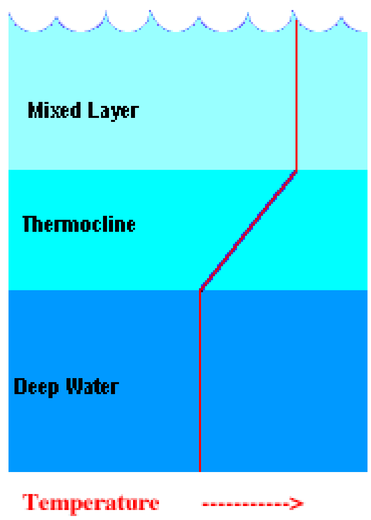

Figure 1.4 Thermocline in a pond or lagoon.

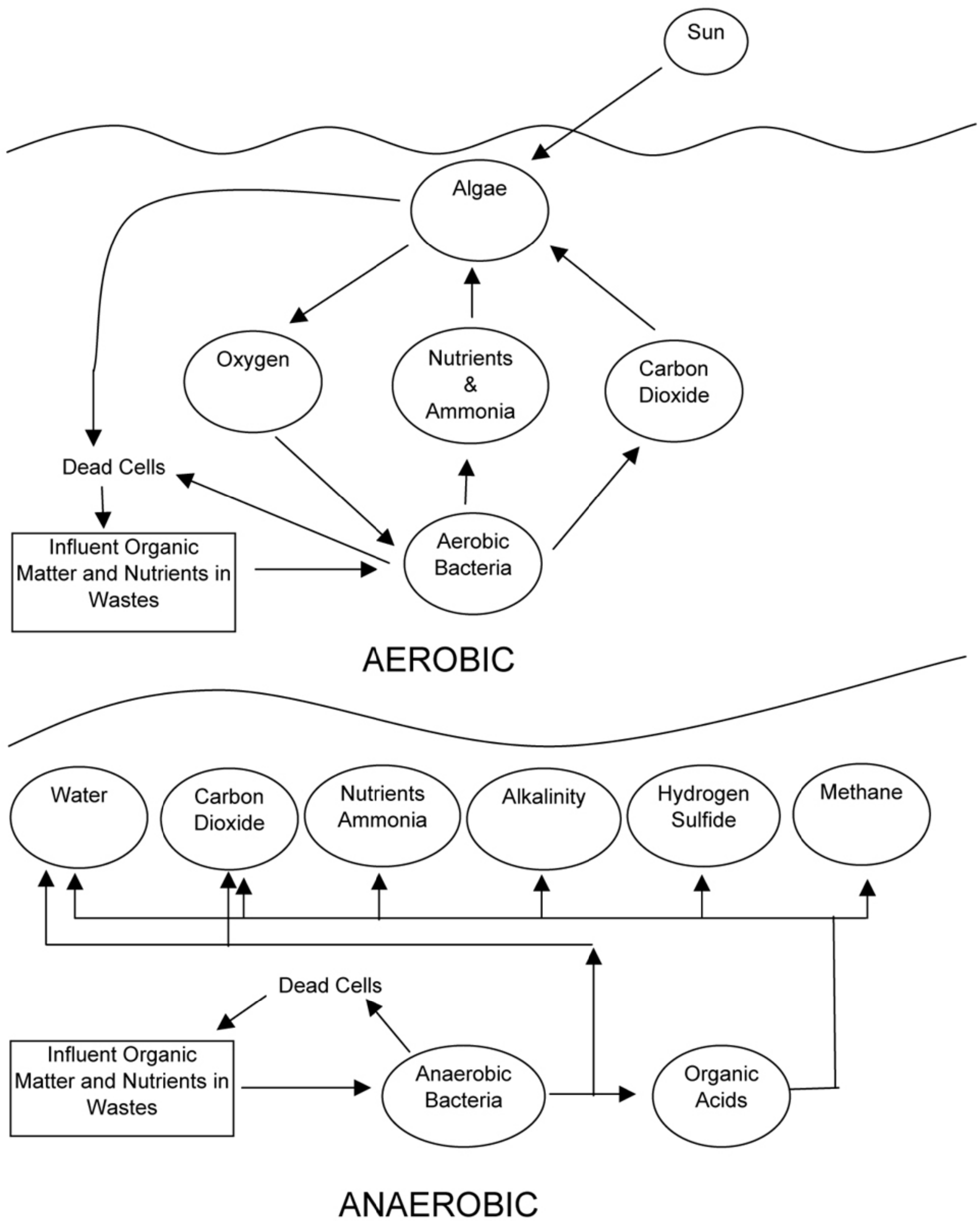

Figure 1.5 Pond Processes[9]

Physical Parameters

In this section, you will learn to identify and calculate important characteristics that help ensure that proper treatment occurs.

Surface Area

Surface area is especially important, as it relates to oxygen transfer in the aerobic zones. Surface area is also used for loading rate calculations. The maximum surface area, as recommended by DEP, is forty acres.

To calculate the surface area of a pond or lagoon, use this formula:

$$\text{Surface area (in acres)} = \frac{\text{(Surface width, in feet) x (Surface length, in feet)}}{43{,}560}$$

NOTE: The bottom number (denominator) in this equation is simply a conversion factor used to change square feet into acres. (1 acre = 43,560 square feet)

Try this exercise together as a class:

Surface Length = 700 feet
Surface Width = 400 feet
Depth = 5 feet
What is the surface area of the pond?

Volume

Treatment by ponds and lagoons typically is slower than by conventional treatment processes. For this reason, large volumes are required to drive the system. The volume calculation is relatively simple; however, you must remember that a typical pond will have sloped sides. Therefore, use the average length, width, and depth of the pond in your calculations.

To calculate the volume, use this formula:

Volume (in gallons) = (Average Length) x (Average Width) x (Average Depth) x 7.48 (in gallons)

NOTE: 7.48 gallons is simply a conversion factor to change cubic feet (ft^3) into gallons. (1 ft^3 = 7.48 gallons)

Try this exercise together as a class:

Average Length = 700 feet
Average Width = 400 feet
Average Depth = 5 feet
What is the volume of the pond?

Detention Time

The length of detention in a pond is important because it determines how much time the processes have in which to occur.

- < 3 days of detention time will allow sedimentation and settling; very little treatment occurs.
- 3 – 20 days of detention time produces abundant algae but only allows transfer of organic material from one form to another.
- > 20 days of detention time provides sedimentation and stabilization of algae so a definite stabilization of wastewater occurs.

Short-circuiting occurs when there is no water movement in a portion of a pond. Short-circuiting leads to the creation of a dead spot, or dead zone, in the pond. This problem will lower the detention time of the pond and could reduce treatment efficiencies. Short-circuiting is caused by poor inlet/outlet piping design, bottoms that are not level, improper pond shape, or a predominant wind direction that does not allow adequate circulation.[10]

To calculate the detention time that a pond or lagoon requires for wastewater treatment, use this formula:

$$\text{Detention time (in days)} = \frac{\text{Pond Volume (in gallons)}}{\text{Influent Flow (in gallons/day)}}$$

Try this exercise together as a class:

Pond Volume = 5 million gallons
Influent Flow Rate = 0.125 million gallons per day (mgd)
What is the detention time of this pond?

NOTE: 0.125 million gallons per day translates into 125,000 gallons per day.

Depth

The depth of a pond can vary from 1 to 20 feet. Several factors affect the depth of the pond or lagoon.

- Aeration requirements
- Vegetation control
  - At least 3 feet is required to drown aquatic weeds, such as tules.
- Sludge protection
  - Sufficient depth should prevent exposure of sludge blankets to the atmosphere.

Oxygen Requirements

Oxygen requirements vary according to the type of pond. Aerated, or aerobic, ponds should maintain a minimum dissolved oxygen (DO) level of 2.0 mg/l throughout the entire pond at all times. This allows bacteria and microorganisms to stabilize waste efficiently and without stress. The oxygen requirements are dependent upon the Biochemical Oxygen Demand (BOD) loadings, as well as the degree of treatment and the concentration of suspended solids that need to be maintained.

Non-aerated, or anaerobic, ponds contain bacteria that do not require DO in order to survive. In fact, the presence of DO will encourage undesired aerobic organisms to flourish; this upsets the pond's balance and lowers the treatment removal efficiency.

Facultative ponds, as you recall, contain aerobic and anaerobic layers as pond strata. It is important to meet the needs of each stratum to ensure that the symbiotic relationship is functional.

Refer to the following chart in order to review the design parameters you learned in this section:

	Type of Pond			
Parameter	**Aerated (1)**	**Aerobic (2)**	**Facultative (3)**	**Anaerobic (4)**
Detention Time, days	3 - 10	5 - 40	5 - 30	20 - 50
Pond Size, acres	2 - 10	2 - 10	2 - 10	0.5 - 2
Depth, feet	6 - 20	3 - 5	4 - 8	8 - 16
pH	6.5 - 8.0	6.5 - 10.5	6.5 - 9.5	6.5 - 7.2
Temperature Range, °C	0 - 30	0 - 30	0 - 50	6 - 50
Optimum Range, °C	20	20	20	30
BOD Loading (lb/ac/day)	80 -95	60 - 120	50 - 180	200 - 500

(1) Pond includes supplemental aeration (i.e., mechanical or diffused aeration).

(2) Pond does not include any supplemental aeration.

(3) Pond includes supplemental aeration. For ponds without supplemental aeration, typical BOD loadings are about one-third of those listed.

(4) Anaerobic pond utilized for pretreatment of high strength wastes and must be followed by an aerated, aerobic, or a facultative pond.

Figure 1.6 Design Parameters[11]

Key Points for Unit 1 – General Overview

- Ponds and lagoons were one of the earliest wastewater treatment processes dating back more than 3,000 years.
- The three (3) types of ponds are the aerobic, anaerobic and facultative.
- Advantages of ponds and lagoons include they are economical, capable of handling high flows, adaptable to changing organic loads, decreased sludge handling, long design life, serve as wildlife habitat, and consume little energy while disadvantages include may cause odors, require large land area, affected by climatic conditions, may have high suspended solids in effluent and may contaminate groundwater.
- Ponds and lagoons can be used in both series and /or parallel formations in wastewater treatment.
- Ponds and lagoons can be utilized as the main wastewater treatment process, oxidation or stabilization pond, as well as incorporated into conventional treatment process for use as a polishing pond.
- The wastewater treatment process of a pond and lagoon is a natural process based upon the feeding of aerobic and/or anaerobic organisms upon the nutrients in the wastewater and maintaining a balance of the complex interactions of these organisms within the water strata.
- Important design parameters and related formulas and calculations for ponds and lagoons include treatment efficiency, percent removal, surface area, volume and detention time and oxygen requirements.

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Exercise for Unit 1 – General Overview

1. List the three basic types of ponds used in wastewater treatment processes.

   a. ____________________________

   b. ____________________________

   c. ____________________________

2. Aerobic ponds contain dissolved oxygen (DO) throughout the entire depth of the pond all of the time.

   a. True b. False

3. Anaerobic ponds function without dissolved oxygen (DO) and rely on _______________ bacteria at the bottom of the pond to ferment the sludge.

4. Water can flow through ponds connected together in either ____________ or _______________ configurations.

5. The influent to a facultative pond contains 30 mg/l of total nitrogen. What is the percent removal if the effluent contains 6 mg/l of total nitrogen?

6. A thermocline can act as a physical ________________ between surface water and bottom water.

7. A pond is 500 feet long by 200 feet wide and the water is 5 feet deep.
   a. What is the surface area of this pond in acres? (1 acre = 43,560 square feet)

   b. What is the volume of the pond in gallons? (1 ft^3 = 7.48 gallons)

   c. What is the detention time if the influent flow rate is 125,000 gallons per day?

[1] California State University, Sacramento, Department of Civil Engineering, *Operation of Wastewater Treatment Plants Volume , 4th ed*., (Sacramento, CA: The California State University, Sacramento Foundation, 1994).

[2] "Manual of Practice, No. 8," in *Design of Municipal Wastewater Treatment Plants, 4th edition*, Water Environment Federation (1998).

[3] "Manual of Practice, No. 8.

[4] Gordon L. Culp and Nancy Folks Heim, "Performance Evaluation and Troubleshooting at Municipal Wastewater Treatment Facilities Field Manual," *Manual of Operations*, 16, (Washington, DC: Environmental Protection Agency, EPA-430/9-78-001, 1978).

[5] R.B. Joe Hayes and Chuck Zickefoose, "Stabilization Ponds Operations Manual," *Manual of Operations,* 15, (Washington, DC: Environment Protection Agency, EPA-430/9-77-012, 1977).

[6] "Manual of Practice, No. 8."

[7] Domestic *Wastewater Facilities Manual: A Guide for the Preparation of Applications, Reports, and Plans*, (Harrisburg, PA: PA Department of Environmental Protection, Bureau of Water Quality Protection, 362-0300-001, October 1997).

[8] "Manual of Practice, No. 8."

[9] "Biological Processes of Ponds," in *Operations of Wastewater Treatment Plants*, California State University.

[10] R.B. Joe Hayes and Chuck Zickefoose, "Stabilization Ponds Operations Manual."

[11] Metcalf and Eddy*, Wastewater Engineering: Treatment, Disposal, Reuse, 3rd ed*., (McGraw-Hill: 1991).

Unit 2 – General Operation and Maintenance

Learning Objectives

- List the three general types of factors affecting pond operation.
- Describe how the dissolved oxygen level in a pond impacts its operation.
- Describe the types and functions of organisms found in a treatment pond.
- List the five types of pond structures and the maintenance strategies of each one.
- List four items that should be tracked in operation logs and two reasons for tracking.

Pond operations are influenced by many different factors which can be generally grouped into three main categories: physical factors; biochemical factors; and microbiological factors. Each of these topics is covered in depth in this unit.

Physical Factors

Six physical factors that affect pond operation are: surface area; depth; hydraulic load; type of aeration; temperature; and incoming flow variations.

Surface Area

- The designed surface area of a pond is determined by the organic loading into the pond (lbs. of BOD per day, per acre of surface area). This is known as the Surface Organic Load rate, and will be discussed later in the unit.

- The type of pond is determined by this organic load rate.[1]
  - Anaerobic ponds can handle more lbs. of BOD per day, per acre, than a facultative pond.
  - A facultative pond can handle more lbs. of BOD per day, per acre, than an aerobic pond.

Depth

The depth of a pond or lagoon will determine the types of strata, or layers, of the pond. The layers can be aerobic or anaerobic. These layers each provide a unique environment in which different treatment processes occur.

- Aerobic processes occur near the surface of a pond.
  - Algae growth
  - Wind-aided surface aeration
  - Mechanical agitation or surface mixers

- Anaerobic processes occur near the bottom of a pond.
  - Bacteria-fermenting sludge require warm, oxygen deprived environment

Hydraulic Load

Hydraulic Load is the height (in inches) of the average volume of wastewater introduced into a pond in one day.

To determine the hydraulic load of a pond, use this formula:

$$\text{Hydraulic Load (inches per day)} = \frac{\text{Depth of Pond, inches}}{\text{Detention time, days}}$$

Try this example as a class:

Width of Pond = 700 feet
Length of Pond = 400 feet
Depth of Pond = 5 feet
Influent Flow = 275,000 gpd
Detention Time = 38 days

Type of Aeration

The mode of aeration in a pond will significantly affect the pond treatment operation. The type of pond, organic loadings, and surface area and depth all determine which combination of aeration methods is employed. Four general methods of aeration can be employed in a treatment pond.

- Algae growth
  - Dissolved oxygen is produced as a waste product by algae during photosynthesis.
  - Photosynthesis is a process by which algae utilize sunlight for energy to break down organic waste for growth.
- Wind-aided surface aeration
  - Tiny ripples on the pond surface are created by wind gusts which will entrap dissolved oxygen in the water.
  - This is a small scale, natural variation of mechanical agitation devices.
- Mechanical agitation or surface mixers
  - Mechanical devices agitate the water surface to cause spray and waves so that oxygen can be absorbed from the air.
  - Types of mechanical aeration devices
    - Paddle wheels
    - Mixers
    - Rotating brushes
    - Floating aerators

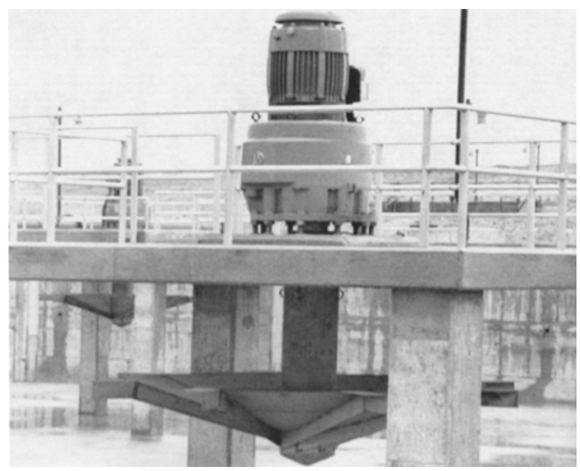


Figure 2.1 Mechanical Agitation[2]

- Diffused aeration
  - Air from a blower system is discharged into the wastewater.
  - Diffusers break up the air stream into fine bubbles.
  - The smaller the bubbles, the greater the oxygen transfer.

Figure 2.2 Diffused Aeration[3]

Temperature

- Water will hold more dissolved oxygen (DO) at colder temperatures than at warmer temperatures.
  - Water in the winter can hold nearly twice as much DO as in summer.
- Biological activity decreases as temperature decreases.
  - A 10º C drop in temperature will reduce microbial activity by one-half.

The highest removal efficiencies occur in warm weather with ample sunlight and a moderate breeze.

Incoming Flow Variations

- Diurnal Flow Variations are the cyclic changes in flow over a 24-hour period.
- Typically, flow is higher during the day, peaking in morning and evening, and lower at night.
  - The flow intensity will roughly correspond with activity and water usage of the people in the service area.
  - Runoff and infiltration from storm events or snow melts will significantly increase the influent flow.

The higher the influent flow rate, the lower the detention time in the pond.

The lower the detention time, the lower the pollutant removal efficiencies.

Biochemical Factors

Four biochemical factors that significantly affect pond operation are: **surface organic load rate; pH; dissolved oxygen levels; and alkalinity.** Additional topics covered in this section will include **nutrient levels; influent toxicity; and sampling and testing.**

Surface Organic Load Rate

Remember from the previous section that the surface organic load rate is defined as the pounds of Biochemical Oxygen Demand (BOD) introduced into the pond per day, per acre of surface area.

- Typical organic loading of a facultative pond is 15 -35 lbs. BOD/day/acre.[5]

To determine the organic load of a pond, use this formula:

$$\text{Organic Load (lb. BOD/day/acre)} = \frac{\text{(BOD, mg/L) x (flow, mgd) x (8.34 lb./gallon)}}{\text{(Area, acres)}}$$

Try this example as a class:

Width of Pond = 700 feet
Length of Pond = 400 feet
Depth of Pond = 5 feet
Influent Flow = 275,000 gpd
Influent BOD = 240 mg/L

pH

- Treatment in a pond occurs best under alkaline conditions.
    - The optimum pH range is typically between 6.5 and 10.5.

- Pond color can be related to the pH of the pond.
    - Green indicates a high pH, or an alkaline environment.
    - Yellow-green indicates a lower pH, or a more acidic environment.

- Bacteria produce carbon dioxide (CO_2), which also causes pH to lower to a more acidic environment. Algae consume carbon dioxide (CO_2) through photosynthesis thereby causing an increase in pH in the pond.

Dissolved Oxygen Level

- Oxygen demand is the amount of DO required by bacteria to oxidize (or break down) the influent organic waste.

- Oxygen demand is directly proportional to the organic strength of the influent waste.

Bacteria require DO to remove the organic waste. As the amount of organic waste increases, so does the amount of DO required. Oxygen requirements, therefore, are dependent upon BOD loading, as well as the degree of treatment and the concentration of suspended solids maintained.[6]

The strength of the waste can be indirectly measured by the Biochemical Oxygen Demand (BOD) test.

- The BOD test measures the strength of the wastewater by measuring the amount of DO used by bacteria as they stabilize the organic waste under controlled time and temperature conditions.

- Main components of the BOD test include the following:
    - A sample of a known volume of wastewater is tested for initial DO concentration.
    - The sample is incubated at 20º C for 5 days.
    - The final DO concentration is determined on the sample.
    - A calculation using the initial and final DO and sample volume is used to determine the BOD value in mg/L.

The BOD test is based on the premise that <u>all</u> biodegradable organic waste will be oxidized to carbon dioxide (CO_2) and water (H_2O) in the presence of dissolved oxygen (O_2).

Alkalinity

Alkalinity is an indication of the acid neutralizing capacity of the wastewater and its resisitance to changes in pH. The major components of alkalinity are carbonate (CO_3) and bicarbonate (HCO_3) species. Alkalinity is repoorted as mg/L as equivalent calcium carbonate ($CaCO_3$).

- High alkalinity wastewater allows a wastewater treatment plant to better survive an acidic industrial discharge.
  - A low pH industrial discharge has the potential to negatively impact the chemical balance of a pond and disrupt the treatment process by stressing or killing algae and bacteria that are needed for organic waste removal.
  - The characteristics of the raw water supply influence alkalinity, which can be very high in areas having “hard water” or very low in areas having “soft water.”

- Aerobic processes decrease alkalinity.
  - BOD removal causes a slight decrease in alkalinity.
  - Ammonia (NH_3) removal, also known as nitrification, causes a significant decrease in alkalinity.
    - NH_3 is converted to NO_2 then to NO_3 in the nitrification process.
    - In addition to requiring oxygen, nitrifying bacteria consume bicarbonate alkalinity (HCO_3) and produce carbonic acid (H_2CO_3).
    - Theoretically, 7.14 lb. of alkalinity is consumed during the oxidation of 1 lb. of NH_3.

- Anaerobic or Anoxic processes increase alkalinity.
  - When DO is not available, nitrate (NO_3) is used as an oxygen source; this condition is referred to as “anoxic.”
    - NO_3 removal, also known as denitrification, causes a slight increase in alkalinity.
    - NO_3 is converted to N_2 gas.
    - Theoretically, 3.57 lb. of alkalinity is created during the reduction of 1 lb of NO_3.
  - When DO and NO_3 are not available, sulfate (SO_4) is used as an oxygen source; this condition is referred to as “anaerobic.”
    - Organic nitrogen is used as a food source, which causes a significant increase in alkalinity.
    - This leads to the generation of ammonia (NH_3).

Nutrient Levels

Without a sufficient supply of certain nutrients, bacteria and algae will not be able to survive or grow. These nutrients are, therefore, limiting factors in the biological treatment efficiency of ponds.

- The main nutrients required are nitrogen and phosphorus.
  - Both of those nutrients are typically found in sufficient quantities in wastewater.
  - Nitrogen is found in the form of ammonia (NH_3).

Influent Toxicity

The introduction of toxic discharges into a pond can adversely impact the natural processes occurring within the pond. Toxins will lead to pond imbalance and lower the treatment removal efficiencies.

- Toxic influent wastewater can lower the DO levels in the pond, stressing bacteria and microorganisms.

- Toxic influent wastewater can kill bacteria and microorganisms.

Routine influent analyses, such as pH and DO, will indicate the presence of toxic discharges. Quick reaction to such discharges minimizes the damage to biological treatment processes of the pond.

Sampling and Testing

Proper laboratory testing is required to maintain a treatment pond or lagoon at optimum efficiency. Testing is done to meet regulatory requirements and to maintain process control. Samples are typically collected from three locations: pond influent; pond body; and pond effluent.

The most common source of laboratory error is sampling. Sampling a pond or lagoon presents special challenges due to a pond's inherent lack of complete mixing. A sample should be well mixed and representative of the entire flow. In order to obtain a representative sample, take care to follow the guidelines below.

- Influent samples could be taken from a wet well or manhole prior to the pond inlet.

- Effluent samples could be taken from the outlet control structure or a well-mixed point in the outfall channel.

- A representative sample needs to include four equal portions from the four corners of the pond.

Take the sample about 8 feet from the water's edge and about one foot below the water's surface

Microbiological Factors

The living organisms that treat organic wastes have a huge effect on pond operation. This section will examine **bacteria (aerobic and anaerobic); algae; and other microorganisms found in a treatment pond.**[7]

Since ponds and lagoons are natural systems and, therefore, not completely or actively mixed, treatment is not uniform throughout the process. In general, the microbial population will be greatest near the influent and will decrease towards the outer edge of the pond due to settling of material. This phenomenon will create unique treatment efficiencies throughout the pond.

Bacteria

Bacteria are divided into two general categories: aerobic and anaerobic.

Bacteria may also be classified both by the mode by which they obtain their energy. Classified by the source of their energy, bacteria fall into two categories: heterotrophs and autotrophs. **Heterotrophs** derive energy from breaking down complex organic compounds that they must take in from the environment. The other group, the **autotrophs**, fixes carbon dioxide to make their own food source; this may be fueled by light energy (**photoautotrophic**), or by oxidation of nitrogen, sulfur, or other elements (**chemoautotrophic**). While chemoautotrophs are uncommon, photoautotrophs are common and quite diverse. They include the cyanobacteria, green sulfur bacteria, purple sulfur bacteria, and purple nonsulfur bacteria. The sulfur bacteria are particularly interesting, since they use hydrogen sulfide as hydrogen donor, instead of water like most other photosynthetic organisms, including cyanobacteria.

Bacteria are simple, single-celled organisms which feed on the organic waste in a treatment pond. Their general form is typically spherical, cylindrical, or helical.

Under a microscope, bacterial colonies would appear similar to this:

Aerobic Bacteria

- Aerobic bacteria require oxygen for respiration.
    - These bacteria break down and stabilize organic substances into soluble material, which is converted into energy.
    - Waste products include carbon dioxide (CO_2), ammonia, and phosphates
        - These waste products, in turn, are essential food requirements for algae.

Anaerobic Bacteria

- Anaerobic bacteria do not require oxygen for respiration.
    - These bacteria decompose and stabilize settled organic solids on the bottom layer of the pond.
    - Two unique and interrelated processes occur.[8] Acid formation and Methane production.
        - Acid forming bacteria convert complex organic compounds (such as carbohydrates, fats, and protein) into simple organic compounds (volatile organic acids).
        - Methane-production is a two-stage process.
            - Bacteria convert the volatile organic acids into carbon dioxide (CO_2), acetate, and hydrogen gas.
            - Methane-forming bacteria convert the CO_2, acetate, and hydrogen gas into methane gas (CH_4).
            - The waste stabilization occurs during the methane production process, since the acid formation byproducts still produce an oxygen demand.
    - Certain anaerobic bacteria are sulfate-reducing bacteria.
        - These bacteria reduce sulfate to hydrogen sulfide (H_2S) when BOD and sulfate are present and no DO is available.
        - These bacteria are not common; however, they are a major cause of odors in ponds.

Algae

Algae are microscopic plants or phytoplankton that live either floating or suspending in water, or attached to a submerged surface. Algae contain chlorophyll, which converts sunlight into energy to degrade organic (carbon based) substances into simpler compounds and for growth in a process called photosynthesis.

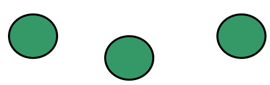
The most important role of algae in the treatment pond life cycle is the production of dissolved oxygen (DO).

Dissolved Oxygen (DO) is produced as a waste product of photosynthesis during active sunlight hours. DO is used by algae for respiration, however, during night hours.

Phosphorus and Nitrogen are inorganic nutrients that are necessary for algae growth.

There are two types of algae: green and blue-green.

- Green algae are mobile and say near the surface.
  - The presence of green algae is indicative of a healthy pond.
  - Green algae are associated with high pH and waste with high nutritional value.
  - Chlorella is a common species found in the treatment pond. Under a microscope it would appear similar to this:



- Blue-green algae cause settling problems and increased suspended solids concentrations.
  - The presence of blue-green algae is indicative of poor pond conditions.
  - Blue-green algae are associated with low pH and low nutrient levels.
  - Blue-green algae are filamentous.
  - Blue-green algae compose most algal "blooms"

One of the most common problems with treatment ponds is typical high suspended solids in the effluent. These solids are mostly composed of algae. A common method of reducing algae in the discharge is to utilize a submerged draw-off point.

Why is algae found near the surface of a pond?

Other Microorganisms

In addition to bacteria and algae, the microbiology of a pond includes more complex single and multi-celled organisms. These organisms feed upon organic matter, bacteria, and algae, thus completing the natural cycle within the pond. We will examine three: protozoa; rotifers; and crustaceans.

These organisms are all aerobic, meaning that they require dissolved oxygen for survival.

Protozoa

- Protozoa are typically microscopic single-celled animals with complex digestive systems that consume both solid organic matter and bacteria and algae as energy sources. They are the next level up on the food chain after the bacteria and algae. Two types of protozoa include *Flagellates* and *Ciliates*.

Flagellates

Flagellates utilize long hair-like strands, known as flagella, for mobility.

Figure 2..3 *Dinomonas Flagellate*[9]

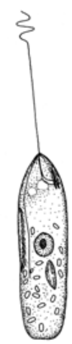


Figure 2.4 *Peranema Flagellate*[10]

Ciliates

There are two different types of ciliates: Free-Swimming and Stalked. Free-Swimming Ciliates, like the example in Figure 2.5, utilize cilia for mobility to swim quickly in the water and to ingest organic matter. Stalked Ciliates, like the example in Figure 2.6, are anchored onto suspended particles and utilize cilia for filtering organic waste.

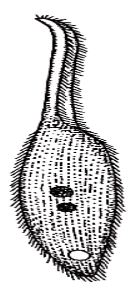


Figure 2.5 *Lionotus Ciliate*[11]

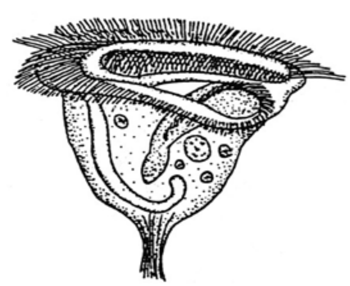


Figure 2.6 *Vorticella Ciliate*[12]

Rotifers

Rotifers are multi-celled organisms. They utilize cilia around their heads for filtering organic waste and bacteria to be metabolized as food. Their presence is an indication of a very efficient biological treatment process and a healthy balance of a treatment pond.

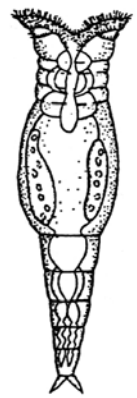


Figure 2.7 *Philodina Rotifer*[13]

Crustaceans

Crustaceans, like the Daphnia example below, are multi-celled organisms with a shell-like covering. They typically have swimming feet or other appendages. They feed mostly upon algae.

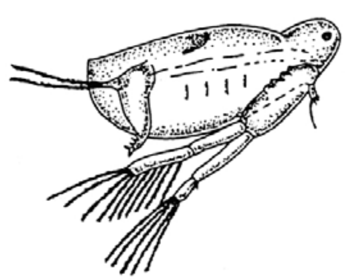


Figure 2.8 *Diaphanosoma Crustacean*[14]

Maintaining Pond Structures

Because ponds are relatively simple to operate, they tend to be the most neglected type of wastewater treatment process unit. Routine maintenance is necessary to ensure the proper functioning of a treatment pond. This section of the training session will focus on the pond structures: headworks, transfer piping, transfer structures, embankments, animal burrows, and aerator maintenance.

Headworks

The headworks of the pond need to be maintained to achieve uniform loading distribution. Scum and vegetation should be removed promptly from the headworks. Also, remove any rags or large debris that might clog piping or pumps.

- Bar Screen maintenance involves removing rags and debris as frequently as necessary.
- Grit Chamber maintenance involves removing heavy grit material from the waste stream and keeping trash shredders free of jams or potential jams.

Transfer Piping

Routine inspection of all transfer piping should be performed.

- Look for cracks or leaks in the piping.
- Flush lines periodically to ensure that no buildup of debris could cause blockage.
- Exercise valves every month or two if they do not receive regular use.

Transfer Structures

Often, multiple inlets and outlets are utilized to improve pond circulation. Distributing the flow will effectively split hydraulic and organic loads equally throughout the pond, or cell, and will eliminate short-circuiting of the structure.

- Inlet Structure maintenance involves the inlet valve and the submerged inlet.
  - Keep inlet valve free of biological growth and keep from freezing.
  - Keep submerged inlet free of floating materials.

- Outlet Structure maintenance typically permits control of the rate of discharge and the pond depth.
  - Surface Outlet maintenance involves a simple baffle to keep floating material out of the effluent.
  - If odor or foam problems persist, a submerged outfall might need to be constructed.

Embankments

A pond's embankments should be inspected routinely; look for damage that could compromise the stability of the structure. Levee banks should be compacted or sealed to prevent leaking.

The top width of an embankment should be wide enough to allow access for maintenance vehicles; this width is typically ten feet.[15]

Two common problems with embankments are erosion and animal burrows.

- Embankment erosion is caused by the wave action or surface runoff.
  - This is a potentially serious problem.
  - Stone riprap or broken concrete rubble will protect levees from erosion.
  - Semi-porous plastic sheeting or liners will prevent erosion and discourage weed growth.
    - Bentonite and other synthetic liners are well-suited to this purpose.
  - Low-growing, perennial vegetative groundcover, such as native grasses, will prevent erosion from surface runoff.
    - Groundcover should be able to be mowed easily.
    - Long-rooted crops, such as alfalfa, should not be used since the roots of the vegetation could impair the water holding efficiency of the embankments.[16]

Animal Burrows

Animal burrows destabilize a levee and present a safety hazard to plant personnel. Rodents dig partially submerged tunnels into the levees. Eventually, these tunnels can weaken the embankment to the point of failure.

Aerator Maintenance

Three types of maintenance will help a pond's mechanical aerators to function well.[17]

- *Routine maintenance*, such as an oil change, is a preventive measure and should be performed according to the equipment manufacturer's recommendations.
- *Equipment repairs* should be performed in a timely manner to lessen further damage to the equipment and to maintain sufficient equipment availability.
- *Debris removal*, including wood and rags, will help prevent damage to mechanical aerators.

Controlling Vegetation

Weeds and vegetation need to be continuously controlled around the perimeter of a pond and within the pond. There are three basic types of vegetation in the pond environment: **emergent weeds; suspended vegetation; and dike vegetation.**

Emergent Weeds are aquatic weeds, such as tules, that grow in the shallow waters at the edge of ponds.

- Emergent weeds hinder pond circulation.
  - They can cause short-circuiting, wherein there is no water movement occurring in a portion of the pond and a "dead zone" is created.
  - They stop wave action, allowing scum to collect.
- Emergent weeds create sheltered areas for mosquito breeding.
- The area provides food for burrowing animals.
- Root penetration from the weeds can cause leaks in the pond's seal.

Suspended Vegetation is floating matter, such as duckweed, that is suspended in the pond waters.

- Suspended vegetation blocks or limits algae and bacteria growth.
- Suspended vegetation lowers treatment efficiencies.
  - It blocks sunlight penetration.
  - It prevents wind action, reducing oxygen introduction.

Dike Vegetation includes weeds that grow on the pond embankments.

- Dike vegetation creates a safety hazard for personnel.
- Dike vegetation creates habitat for undesirable wildlife.

Maintaining Operation Logs

A written record of all operation statuses and changes should be maintained for process control and to meet regulatory requirements. Besides meeting the requirements of a facility's DEP permits for testing frequency and parameters, this data will allow an operator to better understand the unique operation of a particular treatment pond.

Always record the following data, as specified by your site's operating guidelines:

- Water temperature and pH.
- Dissolved oxygen levels.
- Influent and Effluent BOD and TSS.
- Water depth.
- Number of aerators in operation.

Key Points Unit 2 - General Operation and Maintenance

- Physical, biochemical and microbiological factors affect the operation and treatment efficiency of a pond and lagoon.
- Physical factors include surface area, depth, hydraulic load, type of aeration, temperature and influent flow variations.
- Biochemical factors include surface organic load rate, pH, DO levels and alkalinity.
- Microbiological factors that affect the operation of a pond and lagoon include the type of organisms found in the pond and lagoon and maintaining a balance between the populations of these organisms.
- Routine maintenance of the headworks, transfer piping, transfer structures, embankments and aerator maintenance are necessary to ensure the proper functioning of a pond or lagoon.
- Weeds and vegetation including emergent, suspended and dike must be controlled around the perimeter as well as within the pond and lagoon.

Exercise for Unit 2 – General Operation and Maintenance

1. Factors that can affect the operation and treatment efficiency of a pond or lagoon include:
   a. physical
   b. biochemical
   c. microbiological
   d. all of the above

2. Hydraulic load is the height in inches of the average volume of wastewater introduced into a pond in one:
   a. hour
   b. day
   c. week
   d. month

3. Water in the winter months can hold nearly twice as much dissolved oxygen (DO) as in the summer.
   a. True b. False

4. List four biochemical factors that can significantly affect pond operation.
   a. ______________________________
   b. ______________________________
   c. ______________________________
   d. ______________________________

5. ______________ bacteria require oxygen for respiration, but ____________ bacteria do not require oxygen for respiration.

6. Protozoa are classified into two broad groups called ____________ and ______________.

7. The three basic types of vegetation in a pond environment are: ______________, ______________, and ______________.

8. List five items that should be recorded in your maintenance operation logs.
   a. ______________________
   b. ______________________
   c. ______________________
   d. ______________________
   e. ______________________

9. Using the skills you have learned in the preceding units, calculate the surface area, volume, detention time, hydraulic load, and organic load of a pond with the following dimensions, influent BOD, and flow rate:

Surface Length = 200 feet	Average Length = 190 feet	Influent Flow = 15,000 gallons per day
Surface Width = 50 feet	Average Width = 40 feet	Influent BOD = 110 mg/L
	Depth = 5 feet	

SURFACE AREA:

VOLUME:

DETENTION TIME:

HYDRAULIC LOAD:

ORGANIC LOAD

[1] R.B. Joe Hayes and Chuck Zickefoose, "Stabilization Ponds Operations Manual," Manual *of Operations,* 15, (Washington, DC: Environment Protection Agency, EPA-430/9-77-012, 1977).

[2] California State University, Sacramento, Department of Civil Engineering, *Operation of Wastewater Treatment Plants Volume II , 5th ed.*, (Sacramento, CA: The California State University, Sacramento Foundation, 2001), p. 24.

[3] California State University, Sacramento, Department of Civil Engineering, *Operation of Wastewater Treatment Plants Volume II , 5th ed*., p. 25.

[4] R.B. Joe Hayes and Chuck Zickefoose, "Stabilization Ponds Operations Manual."

[5] R.B. Joe Hayes and Chuck Zickefoose, "Stabilization Ponds Operations Manual."

[6] Domestic *Wastewater Facilities Manual: A Guide for the Preparation of Applications, Reports, and Plans*, 1997.

[7] R.B. Joe Hayes and Chuck Zickefoose, "Stabilization Ponds Operation Manual."

[8] "Anaerobic Lagoons" in *Wastewater Technology Fact Sheet*, Environmental Protection Agency, Washington, DC.

[9] Lenore Clesceri, Arnold Greenberg, and Andrew Eaton, eds., *Standard Methods for Examination of Water and Wastewater, 20th Edition*, (American Public Health Association: 1998).

[10] Lenore Clesceri *et al*, *Standard Methods for Examination of Water and Wastewater.*

[11] Lenore Clesceri *et al*, *Standard Methods for Examination of Water and Wastewater.*

[12] Lenore Clesceri *et al*, *Standard Methods for Examination of Water and Wastewater.*

[13] Lenore Clesceri *et al*, *Standard Methods for Examination of Water and Wastewater*.

[14] Lenore Clesceri *et al*, *Standard Methods for Examination of Water and Wastewater.*

[15] Domestic *Wastewater Facilities Manual.*

[16] *Domestic Wastewater Facilities Manual.*

[17] R.B. Joe Hayes and Chuck Zickefoose, "Stabilization Ponds Operation Manual."

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Unit 3 – Typical Operating Problems

Learning Objectives

- Identify potential causes of poor effluent quality, monitoring and solutions to poor effluent quality.
- Identify potential causes of low DO, monitoring and solutions to low DO in a pond and lagoon.
- Define spring and fall turnover in a pond and lagoon.
- Identify potential causes of odor in a pond and lagoon.
- Identify potential causes of falling water levels in a pond and lagoon.
- Explain the potential problems from animal burrows and vegetation, their effects upon the system, and remedies to be utilized to control these problems.

Problems and Solutions Associated with Poor Quality Effluent

Problem	Things to Monitor	Possible Solutions
Aeration Equipment Failure • Improperly working aeration equipment will not maintain the proper DO content in the pond. • Aerobic bacteria and algae will be stressed due to low DO. • Leads to poor treatment efficiency.	• Aeration Equipment Operation • Dissolved Oxygen (DO)	• Make necessary repairs to aeration equipment.
Organic Overload • Excessive organic loading to a pond can not be properly treated to sufficiently remove pollutants to acceptable levels.	• Influent BOD • Influent TSS • Influent DO • Influent pH • Influent Temperature	• Divert a portion of the influent flow to limit organic loading, if possible. • Increase aeration equipment capacity to maintain proper DO. • Recirculate a portion of the effluent flow to dilute the organic strength.
High Total Suspended Solids (TSS) • Algae are found suspended in a pond and, therefore, moderate amounts are expected in the effluent. • Occasionally, elevated levels of suspended solids are experienced as a result of excessive algal blooms.	• Scum • Algal Blooms	• Chemical additions, such as copper sulfate, will help settle algae out of the effluent. • If the problem is severe, constructed wetlands can be added at the end of the pond to help polish the effluent and remove excess algae.

Problems and Solutions Associated with Poor Quality Effluent (continued)

Problem	Things to Monitor	Possible Solutions
Light Blockage • The surface of a pond can become covered with scum or plant growth. • Photosynthesis is the process by which all plants utilize sunlight to produce energy for survival; algae in the pond require sunlight to survive and reproduce. The restriction of sunlight into the pond will result in lower treatment efficiencies.	• Scum • Duckweed	• Remove excessive plant growth from pond surface. • Break up and skim off scum.
Toxic Influent Material • When a toxic substance is discharged into a collection system, the biological processes occurring in the treatment pond can be upset. • This could lead to stressing of the organisms or the complete destruction of the biological treatment population.	• Influent pH • Influent DO • Influent Temperature	• Sample the collection system to identify the cause or source of toxicity. • Develop and implement sewer-use ordinances to establish prohibitions and limitations of substance discharge and criminal fines if discharges occur. • Recirculate a portion of the effluent flow to the influent flow to dilute the influent toxic substance concentration. • Increase surface aeration equipment to maintain proper dissolved oxygen.

Problems and Solutions Associated with Poor Quality Effluent (continued)

Problem	Things to Monitor	Possible Solutions
Loss of Pond Volume • Over time, the sludge blanket on the pond bottom will accumulate to significant depths. • A large sludge blanket will displace a portion of the pond volume, thus lowering the total capacity of the pond.	• Sludge Depth – Utilize a sludge judge or similar device	• Dredge the pond or lagoon to remove accumulated debris. (This is typically only necessary after several years of pond operation.)
Short Circuiting • Condition occurs when there is no water movement in a portion of the pond. • Short circuiting results in reduced treatment efficiencies. • Causes include excessive weed growth, inlet/outlet arrangement, and irregular pond bottom.	• Pond Surface (for visibly stagnant sections of the pond, or “dead zones,” i.e., no water movement or heavy collection of surface scum)	• Install manifolds or diffusers on inlets and outlets. • Provide multiple inlets and outlets for more equal hydraulic distribution. • Change location of inlets and outlets. • Keep inlets and outlets as far apart as possible. • Eliminate “dead zones.”

Problems and Solutions Associated with Low Dissolved Oxygen

Problem	Things to Monitor	Possible Solutions
Low Algae Growth • Algae can provide a significant amount of the dissolved oxygen in a pond. • If algae populations dwindle, the amount of dissolved oxygen produced will decline.	• Dissolved Oxygen Levels (in the influent, in the pond, and in the effluent)	• Recirculate the return effluent flow back into the influent flow. (Return effluent should have higher DO concentrations.)
Excessive Scum Accumulation • A heavy scum layer on the pond surface will block oxygen transfer from the atmosphere. • A heavy scum layer will also block sunlight, which will lower algae production, resulting in lower dissolved oxygen production.	• Dissolved Oxygen Levels (in the influent, in the and, and in the effluent) • Scum	• Break up scum and remove or skim off the surface. • Use rakes, hose with water, or motor boats to break up scum. • Broken scum will usually sink. • Can skim scum off the surface and bury it or haul it to a landfill after proper regulatory agency approval. • Remove excessive pond surface plant growth.
Aeration Problems • Improperly working aeration equipment will not maintain the proper DO content in the pond. • Aerobic bacteria and algae will be stressed due to low DO. • Leads to poor treatment efficiency.	• Aeration Equipment Operation	• Make necessary repairs to aeration equipment.

Problems and Solutions Associated with Low Dissolved Oxygen (continued)

Problem	Things to Monitor	Possible Solutions
Organic Overload • Excessive organic loads to a treatment pond can not be properly treated to sufficiently remove pollutants to acceptable levels.	• Influent BOD • Influent TSS • Influent DO • Influent pH • Influent Temperature	• Divert a portion of the flow in order to decrease organic loading. • Run ponds in parallel mode rather than series mode. • Add Sodium Nitrate
Short Circuiting • Condition occurs when there is no water movement in a portion of the pond. • Short circuiting results in “dead zones” with little or no dissolved oxygen. • “Dead zones” will lead to reduced treatment efficiencies.	• Pond Surface (for visibly stagnant sections of the pond, or “dead zones,” i.e., no water movement or heavy collection of surface scum)	• Install manifolds or diffusers on inlets and outlets. • Provide multiple inlets and outlets for more equal hydraulic distribution. • Change location of inlets and outlets. • Keep inlets and outlets as far apart as possible. • Eliminate “dead zones.”

Problems and Solutions Associated with Pond Odors

Problem	Things to Monitor	Possible Solutions
Anaerobic Conditions • Odors are produced when aerobic conditions are not maintained due to: o Spring/Fall turnovers of deep ponds and lagoons. o Algae die-off. o Organic overloading. o Poor pond circulation. o Scum accumulation on pond surface. o Insufficient sludge.	• Rising Sludge Chunks • High Strength Industrial Waste • Short Circuiting • Rising Sludge Accumulations	• Divert all or a portion of flow to lessen organic loading, if possible. • Use parallel pond mode of operation rather than series mode. • Put additional aeration equipment in service, such as floating aerators. • Recirculate return effluent back to the influent flow to provide additional dissolved oxygen. • Periodically remove sludge buildup from the bottom of ponds. • Break up scum using a rake, hose, or motor boat. • Skim scum or allow scum to sink. • Bury or haul scum to a landfill after checking for regulatory agency approval. • Pre-chlorinate the pond influent flow to oxidize offending material.
Hydrogen Sulfide • Continued organic overloading can lead to septic influent conditions and the presence of hydrogen sulfide in the waste stream. • Hydrogen sulfide can also be a particular problem with anaerobic ponds that lack sufficient scum blanket cover over the water surface.	• Influent BOD • Influent DO	• Pre-chlorinate the pond influent flow to oxidize the hydrogen sulfide and eliminate it. • Increase or adjust mechanical aerators to eliminate septic conditions caused by lack of dissolved oxygen.

Problems and Solutions Associated with Falling Liquid Levels

Problem	Things to Monitor	Possible Solutions
Leakage of Levees • Leaks can occur due to animal burrows, cracks, soil settlement, or erosion.	• Pond Level Gauges • Sludge Depths • Record Logs	• Determine the location of the leak and repair with plastic lining or bentonite clay. • Remove burrowing animals and fill the established burrows to stabilize the levees and reduce any further structural damage.
Discharge Valve Opened Too Far • Effluent discharge lines can have an adjustable valve. By adjusting this valve, the water level in the pond can be raised or lowered as needed.	• Pond Level Gauges • Discharge Valve Position	• Adjust discharge valve to achieve desired water level.
Plugged Inlet Lines • Debris can accumulate in the influent line to the pond and plug the line.	• Influent Flow Meter (if the influent flow rate suddenly drops from its usual level, the problem is therefore occurring upstream of the metering point)	• Clean out inlet lines and remove debris. • Flush lines on a routine basis.

Problems and Solutions Associated with Animal Burrows

Problem	Things to Monitor	Removal Techniques
Animals Burrowing • Burrows compromise the stability of the structure. • Safety of plant personnel is compromised, as burrows are a tripping hazard. • Burrows can damage equipment during transport around the edges of a pond.	• Leaks • Excessive Vegetation • Holes and tripping hazards	• Remove food supply, such as emergent weeds (cattails, burr reed) to discourage the animals. • Live trapping must be done through approved methods; check with PA Game Commission for approval. • Poisoning; always get approval and use authorized techniques and personnel only. • Flooding the burrows will remove the animals.

Problems and Solutions Associated with Excessive Vegetation

Problem	Things to Monitor	Possible Solutions
Emergent Weeds • These plants can have a detrimental effect on pond treatment efficiencies. • They can hinder pond circulation and create short circuiting, which leads to “dead zones.” • They provide a mosquito breeding area and food for burrowing animals.	• Pond Depth • Weed Growth	• Maintain a water depth of at least 3 feet within the pond to drown out aquatic weeds, such as tules, which grow in shallow water. • Pull weeds by hand if they are soft, new growth. • Lower the water level to expose weeds and then burn them with gas burner.
Suspended Vegetation • These plants can have a detrimental effect on pond treatment efficiencies. • They can block the penetration of sunlight to algae, which leads to lower algae growth and reduced treatment efficiencies.	• Weed Growth	• Use rakes to remove duckweed. • A board can be used as a skimmer to remove floating vegetation.
Dike Vegetation • These plants can cause a safety hazard to personnel who are attempting to maintain or sample the pond. • They can create habitat for undesired wildlife.	• Weed Growth	• Mow the embankments regularly. • Plant a low-growing ground cover on the embankment to eliminate other, undesirable growth; plant a mixture of fescue and blue grasses on the shore. • Plant native grasses elsewhere. • Use riprap along embankment. • Use herbicides as a last resort; herbicides represent a hazard to operators and to the biological system within the pond. • Check with authorities for approved weed control chemicals and application protocol.

Key Points for Unit 3 – Typical Operating Problems

- Because ponds are deceptively simple, they are probably neglected more than any other type of wastewater treatment process.
- Poor effluent quality including high BOD, high SS, and elevated ammonia or phosphorous levels can be caused by aeration equipment failure, organic overloads, algal blooms, light blockage, influent toxics, loss of pond volume and short circuiting.
- Some common causes of low DO include low algal growth, excessive scum accumulation, aeration problems, organic overloading and short-circuiting.
- Spring and fall turnover is caused by seasonal temperature changes of the ponds surface water when in the spring the surface water begins to warm and again in the fall when the surface water begins to cool.
- Odor is caused by anaerobic conditions and the presence of hydrogen sulfide.
- The most common causes of falling water levels include leakage of levees, discharge value opened to far and plugged inlet lines.
- Animal burrows must be removed promptly and any damage caused by the burrows must be repaired immediately.
- Vegetation including emergent, suspended and dike vegetation must be monitored and harvested periodically to maintain the structural integrity and efficient operation of the system.

Exercise for Unit 3 – Typical Operating Problems

1. Malfunctioning or inadequate aeration equipment can result in low levels of dissolved oxygen (DO) and poor effluent quality.
   a. True
   b. False

2. The addition of the chemical ________________ ___________________ can help to settle algae out of the effluent.

3. It is suspected that a toxic substance has been discharged into the collection system. List three things to monitor in the influent water.

   a. ___________________

   b. ___________________

   c. ___________________

4. The build-up of a sludge blanket on the bottom of a pond will lessen the capacity of the pond. It may be necessary to dredge the pond after a period of _______________ ____________ of operation.

5. A possible solution mentioned for many of the problems in the table is to recirculate part of the ___________________ flow back into the __________________ flow.

6. Explain in an example how the recirculation solution mentioned above can help solve a pond problem.

7. Running ponds in _________________ mode may be a solution if ________________ overload is the suspected problem.

8. List three examples of problems that may produce odors.
   a. __________________
   b. __________________
   c. __________________

9. List three problems or hazards that may be caused by burrowing animals.
   a. __________________
   b. __________________
   c. __________________

10. Explain how the choice of ground cover on a dike can make the maintenance of the dike easier.