Module 19:
Treatment Ponds and Lagoons
Answer Key

What are some undesired effects of discharging wastewater directly into clean water sources?

Ans: Some possible answers include odor, disease, and destruction of habitat.

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

Ans: An aerobic pond, by definition, has DO throughout its entire depth. Shallow depth allows for distribution of DO throughout; a deeper pond would not have an adequate DO supply using natural methodology, such as algae or wind.

Ask students to apply their critical thinking skills to the following questions about facultative ponds:

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

  Ans: Algae; wind; mechanical aeration devices; and diffused aeration can supply DO.

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

  Ans: Aerobic bacteria and algae stabilize organic waste.

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

  Ans: Anaerobic bacteria ferment organic waste in the anaerobic layer.

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

  Ans: It is nearly impossible to maintain completely aerobic or anaerobic conditions in a pond.

Percent Removal Calculation

To determine the percent removal, you should perform this calculation:

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

Percent Removal Calculation Exercise

Now we will perform the calculation using some real numbers. Insert the numbers on the screen into the appropriate spot in the calculation. Figure the answer; remember that the answer you want will be represented as a percentage.

Influent Ammonia Nitrogen = 25 mg/l
Effluent Ammonia Nitrogen = 20 mg/l
What is the percent removal?

Ans: [(25 – 20) / 25] x 100 = 20
The answer is 20%.

Surface Area Calculation

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

Surface Area Calculation Exercise

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

Ans: $\text{Surface area (in acres)} = \frac{\text{700 feet} \times \text{400 feet}}{43{,}560} = \text{6.4 acres]}$

Volume Calculation

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

Volume Calculation Exercise

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

Ans: Volume (in gallons) = 700 feet x 400 feet x 5 feet x 7.48 = 10,472,000 gallons

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Detention Time Calculation

There is an easy calculation that tells us how much time a drop of wastewater will remain in a pond or lagoon.

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

Detention Time Calculation Exercise

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

$$\text{Detention time (in days)} = \frac{5{,}000{,}000 \text{ gallons}}{125{,}000 \text{ gallons/day}} = 40 \text{ days}$$

Ans: $$\text{Detention time (in days)} = \frac{5{,}000{,}000 \text{ gallons}}{125{,}000 \text{ gallons/day}} = 40 \text{ days}$$

Exercise for Unit 1 – General Overview

1. List the three basic types of ponds used in wastewater treatment processes.
   a. aerobic
   b. anaerobic
   c. facultative

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 anaerobic bacteria at the bottom of the pond to ferment the sludge.

4. Water can flow through ponds connected together in either parallel or series 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?

$$\text{Percent Removal (\%)} = \frac{\text{(Influent, mg/l)} - \text{(Effluent, mg/l)}}{\text{(Influent, mg/l)}} \times 100\% = \frac{30 - 6}{30} \times 100\%$$

$$= \frac{24}{30} \times 100\ \% = 80\%$$

6. A thermocline can act as a physical barrier 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)

Area = 500 ft x 200 ft = 100,000 ft^2

$$100{,}000\ ft^2 \times \frac{1\ acre}{43{,}560\ ft^2} = 2.3\ acres$$

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

Volume = 500 ft x 200 ft x 5 ft = 500,000 ft^3

$$500{,}000\ ft^3 \times \frac{7.48\ gal}{1\ ft^3} = 3{,}740{,}000\ gal$$

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

$$\text{Detention Time} = \frac{\text{Pond Volume}}{\text{Influent Flow}} = \frac{3{,}740{,}000\ \text{gallons}}{125{,}000\ \text{gal / day}} = 30\ \text{days}$$

Hydraulic Load Calculation.

The hydraulic load is a means of describing the volume of flow into a pond as it relates to the depth of the pond; the result is the "height" of influent wastewater into the pond on a daily basis. To determine the hydraulic load, you should perform this calculation:

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

Hydraulic Load Calculation Exercise

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

Ans: $$\text{Hydraulic Load} = \frac{(5\ \text{feet})\ (12\ \text{inches/feet})}{38\ \text{days}} = 1.58\ \text{inches/day}$$

Obviously, the hydraulic load will impact a pond's operation. The type of aeration in the pond also affects its operations. Interestingly enough, the aeration method is determined by the previous factors we have discussed, namely, organic loading, surface area, and depth, as well as the type of pond.

After reviewing that portion of the Design Parameter chart from Unit 1, what effect does the type of pond (and its major mode of aeration) have on the amount of organic loading which can be adequately treated by the pond?

Ans: Of the three types of ponds with aerobic zones, aerated ponds are typically able to treat higher minimum organic loading rates. This is because they employ mechanical aeration or diffused aeration equipment, which provide a higher dissolved oxygen transfer rate than the natural methods of algae or wind.

Organic Loading Calculation

To determine the organic load of a pond, you should perform this calculation:

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

Organic Loading Calculation Exercise

Now we will perform the calculation using some real numbers. Insert the numbers on the screen into the appropriate spot in the calculation. Figure the answer. Remember that the answer you want will be represented as pounds of BOD per day, per acre; therefore, you will need to calculate the number of acres of the pond before calculating the organic load.

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

Ans: $$\text{Surface Area (acres)} = \frac{\text{(700 feet) x (400 feet)}}{\text{43,560 square ft/acre]}} = \text{6.4 acres}$$

Next Step

After we determined the acreage, we can use that figure to finish the calculation.

Ans: $$\text{Organic Load} = \frac{\text{(240 mg/L) x (0.275 mgd) x (8.34 lb/gallon)}}{\text{(6.4 acres)}} = \text{86 lb. BOD/day/acre}$$

The answer is 86 lb. BOD/ day/acre

Why is algae found near the surface of a pond?

Ans: Algae require oxygen; in typical facultative ponds, oxygen is most plentiful near the surface. Algae also use sunlight in the photosynthesis process.

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.

   Answers could include: surface organic load rate, pH, DO, alkalinity, nutrient levels, and influent toxicity.

5. _Aerobic_ bacteria require oxygen for respiration, but _anaerobic_ bacteria do not require oxygen for respiration.

6. Protozoa are classified into two broad groups called _flagellates_ and _ciliates_.

7. The three basic types of vegetation in a pond environment are: _emergent weeds_, suspended vegetation_, and _dike vegetation_.

8. List five items that should be recorded in your maintenance operation logs.
   a. _water temperature and pH
   b. _DO
   c. _Influent and effluent DOD and TSS
   d. _water depth
   e. number of aerators in operation

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: Note: in this step, we calculate the entire surface area of the water. The volume calculation in the next step will use the average length and width to account the sloped sides of the pond.

surface area = 200 ft x 50 ft = 10,000 sq ft

$$10{,}000 \text{ sq ft} \times \frac{1 \text{ acre}}{43{,}560 \text{ sq ft}} = 0.23 \text{ acres}$$

VOLUME: Note: to calculate volume, use the average length and average width.

volume = 190 feet x 40 feet x 5 feet = 38,000 cubic feet

convert to gallons: 38,000 ft^3 x 7.48 gallons / ft^3 = 284,240 gallons

DETENTION TIME:

$$\text{Detention time (days)} = \frac{\text{Pond volume (gallons)}}{\text{Influent flow (gal / day)}} = \frac{248{,}240 \text{ gallons}}{15{,}000 \text{ gal / day}} = 19 \text{ days}$$

HYDRAULIC LOAD:

$$\text{Hydraulic Load} = \frac{\text{Depth of pond (inches)}}{\text{Detention time (days)}} = \frac{60 \text{ inches}}{19 \text{ days}} = 3.16 \text{ inches / day}$$

ORGANIC LOAD: note: a BOD of 110 mg/L is the same as a BOD of 110 lb / million lb of water.

$$\text{Organic Load} = \frac{\text{BOD (mg/L)} \times \text{Flow (mgd)} \times 8.34 \text{ (lb/gal)}}{\text{Area (Acres)}}$$

$$\text{Organic Load} = \frac{110 \text{ lb} \times 0.015 \text{ mgd} \times 8.34 \text{ lb/gal}}{1 \text{ million lb} \times 0.23 \text{ acre}} = \frac{60 \text{ lb}}{\text{day} \times \text{acre}}$$

What do you think will be accomplished when we suggest that running ponds in parallel mode rather than series mode may be a solution to the organic overload problem?

Ans: As an example, imagine two identical ponds that can be run either in parallel or series. By running the two ponds in parallel as opposed to series operation, several operating parameters change:

- The volume is doubled because the flow is split into two ponds instead of one, which is twice as large of a volume.
- The detention time is cut in half because the flow, however, only travels through one pond instead of two, which takes half of the time.

Whether you know it or not, you are probably familiar with one of the problems associated with Hydrogen Sulfide. Does anyone know what it smells like?

Ans: It emits that classic "rotten egg" smell.

☑ 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 __copper sulfate__ 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. Influent pH
   b. Influent DO
   c. Influent Temperature

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 several years of operation.

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

6. Explain in an example how the recirculation solution mentioned above can help solve a pond problem. One example would be to increase DO, since effluent usually has a higher DO than influent.

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

8. List three examples of problems that may produce odors.

a. <u>anaerobic conditions</u>

b. <u>presence of hydrogen sulfide</u>

c. <u>Spring/Fall turnover, algae die-off, organic overloading, poor pond circulation, scum accumulation on pond surface, insufficient sludge.</u>

9. List three problems or hazards that may be caused by burrowing animals.
   a. <u>structural stability</u>
   b. <u>tripping hazard</u>
   c. <u>equipment damage</u>

10. Explain how the choice of ground cover on a dike can make the maintenance of the dike easier.
    <u>Can eliminate other undesirable growth, make mowing easier, a low-growing ground cover may improve general appearance.</u>