CHAPTER 4
STABILIZATION LAGOONS

Learning Objectives

This chapter will examine the use of stabilization lagoons and ponds for use in wastewater treatment. In this chapter, the student will gain an understanding at:

- Various types of lagoons used for wastewater treatment;
- The bacterial algae cycle and how it contributes to the treatment process;
- Design and operational parameters for lagoon systems;
- Lagoon safety considerations

LAGOON PROCESS OVERVIEW

Stabilization lagoons (Figure 4.1) are used to treat wastewater before it is discharged to a receiving water. The wastewater is stabilized by active bacteria through a biological treatment process. It is similar to both the natural treatment described in Chapter 1 and the activated sludge and trickling filter processes, where bacteria use organic matter in the wastewater as food.

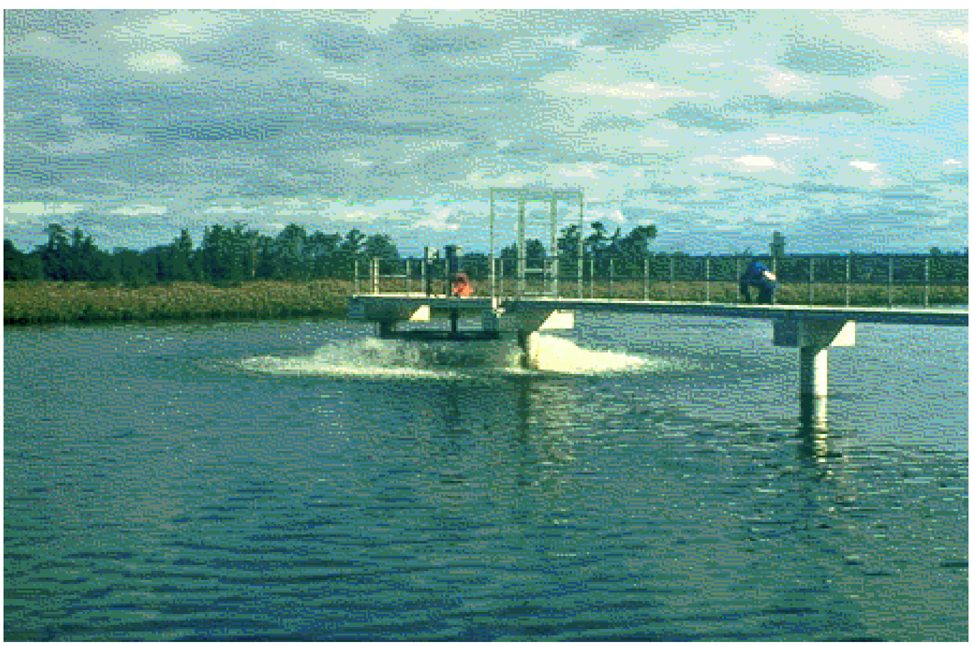

Figure 4.1 Aerated Stabilization Lagoon

There are three types of bacteria at work in most lagoons: aerobic, anaerobic, and facultative. The main difference between these three types of bacteria is their need for dissolved oxygen. Aerobic bacteria need dissolved oxygen to live and grow; anaerobic bacteria live only where no dissolved oxygen is present and facultative bacteria can adapt to either condition. Facultative bacteria can live either with or without the presence of dissolved oxygen. When aerobic and facultative bacteria are active, the process of aerobic decomposition takes place. On the other hand, when anaerobic and facultative bacteria are active, anaerobic decomposition takes place.

Aerobic decomposition stabilizes waste by converting it into carbon dioxide and water. Although anaerobic decomposition stabilizes waste, it also produces methane gas, ammonia, hydrogen sulfide, and other products with unpleasant odors. For this reason, it is important to make sure that enough dissolved oxygen is present in the lagoon to support aerobic and facultative bacteria, rather than anaerobic bacteria. How do we make sure of this? How can we get oxygen into the wastewater so that aerobic decomposition takes place? Luckily, nature helps us out. Oxygen is produced in the water by algae, which are small green plants, some so small that they can only be seen under a microscope. Figure 4.2 is a magnified representation of different kinds of algae.

Figure 4.2 Common Types of Algae

Algae are plants, so they need food, carbon dioxide, water, and sunlight to grow. They use very little of the organic matter in the waste, leaving that for bacteria. In sunlight, the algae grow and produce oxygen, which dissolves in the water. One of the things algae use as food is carbon dioxide. Carbon dioxide is created when aerobic bacteria decompose waste. Conversely, bacteria need oxygen, which is produced by the algae. In other words, bacteria and algae work well together in a waste stabilization lagoon. The algae produce the oxygen needed by the bacteria, and the bacteria in turn produce the carbon dioxide needed by the algae. Let us take a closer look at what happens.

Aerobic bacteria need dissolved oxygen to decompose organic waste. As aerobic decomposition takes place, carbon dioxide as well as new bacteria are produced. If sunlight is present, then algae can use this carbon dioxide to live and reproduce. And as the algae grow more oxygen is produced. This is a continuous, cooperative cycle. Algae produce oxygen used by bacteria to decompose waste. The bacteria produce carbon dioxide, which is used by the algae to produce more oxygen, which is used by the bacteria to produce more carbon dioxide, and so on. The important thing to remember about this entire cycle is that algae will thrive only when sunlight is present. They cannot grow at night, or in locations without sunlight. Also, the water in the lagoons must be reasonably clear and not too deep. In clear lagoons less than 0.6 m

(2 ft) deep, sunlight may reach the bottom, allowing algae to grow throughout the lagoon depth. In shallow lagoons, aerobic bacteria are usually present. But if the water is not clear, or if the sunlight is cut off, algae will not grow. The dissolved oxygen level in the lagoon will decrease, and the level of anaerobic activity at the bottom of the lagoon will increase. These factors will also lead to an increase in the size of the anaerobic layer at the bottom of the lagoon. If the lagoon is more than 1 m (3 ft) deep, sunlight may not be able to penetrate to the bottom. Algae will not grow and the dissolved oxygen concentration drops often as low as zero. This area of the lagoon is called the facultative zone. Because the amount of oxygen present in this zone varies, only facultative bacteria, which can adjust to aerobic and anaerobic conditions, can survive here.

In summary, waste stabilization lagoons are self-contained, complete treatment processes. Nature provides everything needed to stabilize the waste. Wastewater treatment equipment, such as aerators, is used to help manage and control the process if conditions change drastically. Remember, natural processes are very delicate and major changes in the weather and influent characteristics can have devastating results. As the waste enters the lagoon, some of the solids settle to the bottom and are broken down by anaerobic organisms. If the lagoon is operating properly, the products of anaerobic decomposition serve as food for aerobic organisms. If all processes are in balance, a waste stabilization lagoon can provide adequate treatment of the wastewater. But, if only one link in the process chain is broken, the whole lagoon may become upset. If a lagoon is overloaded with too much organic material, or if the sunlight is cut off, the amount of available oxygen will decrease. This can result in anaerobic conditions, loss of treatment efficiency, and nuisance odors. If a floating mat (for example of scum) develops, it will block sunlight. These mats should be broken up or removed to allow sunlight to penetrate. Remember, algae are plants and need sunlight to grow and produce oxygen for the bacteria. As you might expect, the process changes with changes in weather. If the weather becomes cloudy, less sunlight will reach the wastewater. This will slow down the treatment process. Cooler temperatures also slow down bacterial activity.

Some regulatory authorities require that lagoon effluent be disinfected. Bacteria die off more completely in lagoons than in other wastewater treatment methods because of the longer detention time. However, lagoon effluent may still require disinfection to ensure the destruction of pathogenic organisms.

Lagoon Types

We have been reviewing the importance of bacteria and algae in a stabilization lagoon. The bacteria perform the treatment in a lagoon and the amount of dissolved oxygen available determines the kind of bacterial action that will take place.
This means that there are different kinds of waste stabilization lagoons: aerobic, anaerobic, and facultative.

Figures 4.3a and 4.3b show an aerobic waste stabilization lagoon and the decomposition processes that occur in these lagoons. Aerobic lagoons are normally 1 – 1.3 m (3 – 4 ft) deep so that sunlight can reach throughout the entire lagoon. This promotes algae growth, and the oxygen produced allows aerobic microorganisms to live. The lagoon will be aerobic at all depths. Incidentally, another reason for keeping the aerobic lagoon shallow is to control growth of the algae. If the lagoon is too deep the resulting increase in algae, will tend to block off sunlight.

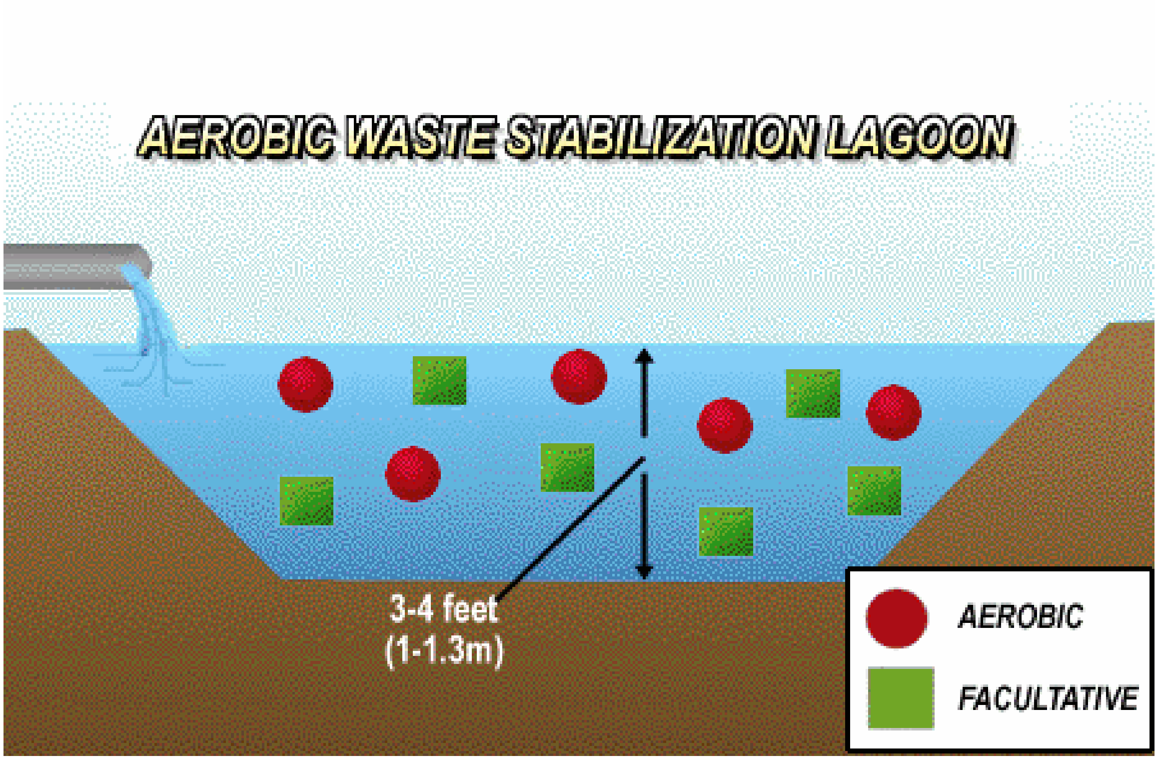

Figure 4.3a Aerobic Stabilization Lagoon

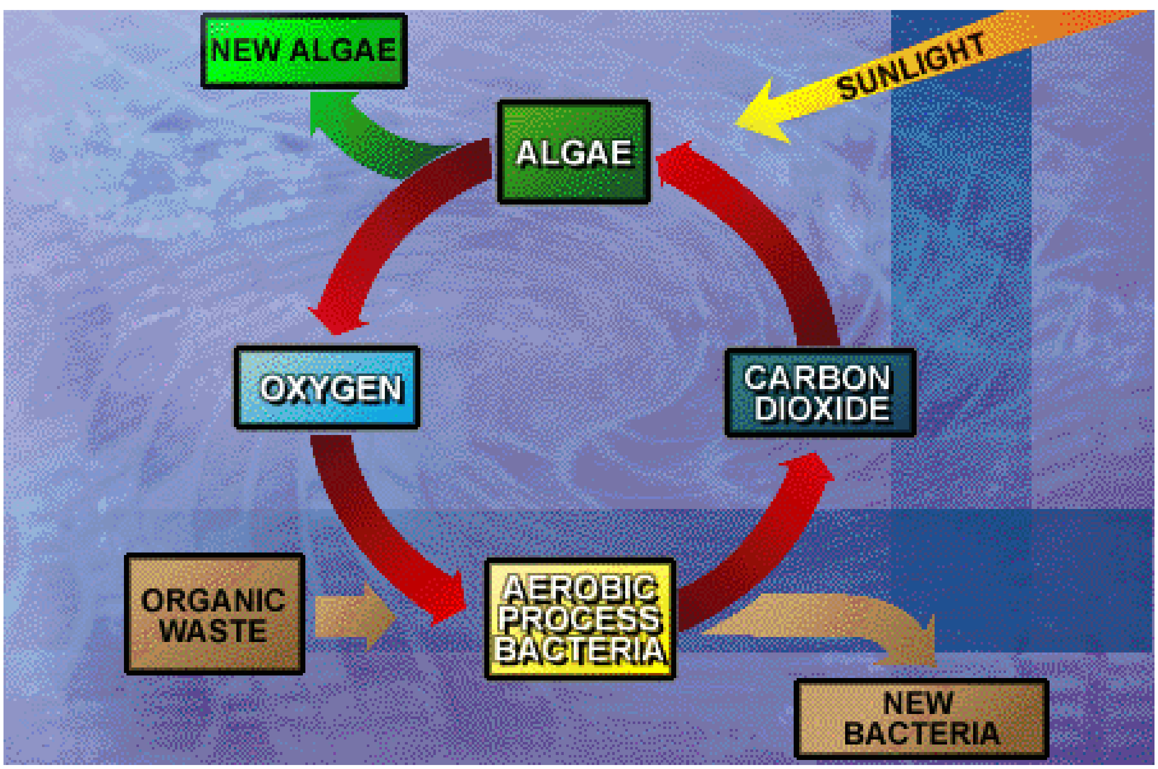

Figure 4.3b Aerobic Decomposition Process

Figure 4.4 shows an anaerobic lagoon and the decomposition processes that occur in these lagoons. Anaerobic lagoons are 2.5 – 5.0 m (7 – 15 ft) deep and are anaerobic throughout. These kinds of lagoons are used to treat concentrated wastes, like those that come from a food-processing industry. Most anaerobic lagoons are covered with a layer of scum. This scum stops air from mixing with the wastewater. No dissolved oxygen will exist in the lagoon, and anaerobic bacteria will be at work. Because the gases produced by anaerobic bacterial action can cause odor problems, the use of these lagoons is not widespread. If anaerobic lagoons are used, they are located away from residential areas, provided with some form of odor control measures or both.

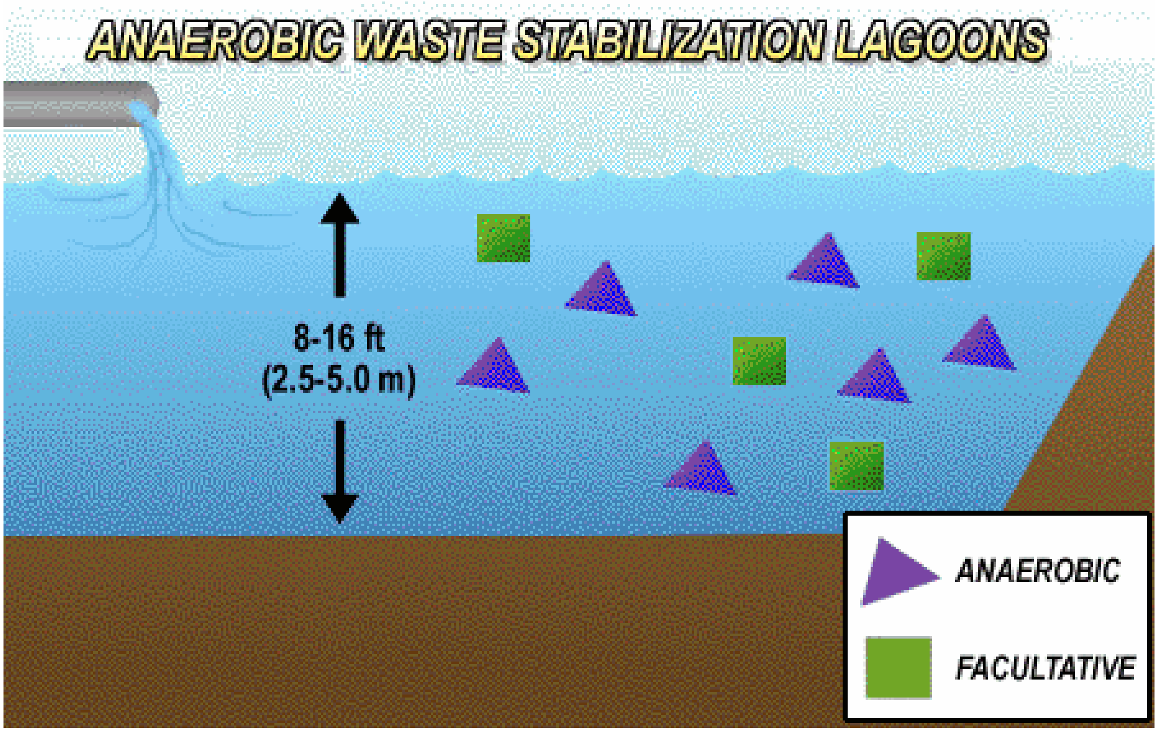

Figure 4.4 Anaerobic Stabilization Lagoon

The facultative lagoon (Figure 4.5) is the type of lagoon used most often to treat municipal wastewater and some industrial wastewaters. Facultative lagoons are usually 1 – 2 m (3 – 6 ft) deep. The sludge at the bottom is anaerobic, while the top 0.3 – 0.6 (1 – 2 ft) m of the lagoon is aerobic. In the middle, the amount of dissolved oxygen varies, and either aerobic or anaerobic decomposition will take place, depending on how much oxygen is available. It is important to have enough dissolved oxygen in the wastewater, to allow bacterial action. In an aerated waste stabilization lagoon, shown here, air is diffused into the wastewater. Supplying more oxygen than the algae can produce on their own allows the operator to either increase the wastewater load or shorten the retention time in the lagoon. We will deal with both facultative and aerated lagoons in more detail later in this unit, because they are the types of lagoons that are most often used. Table 4.1 provides fundamental parameters for each of the discussed lagoons.

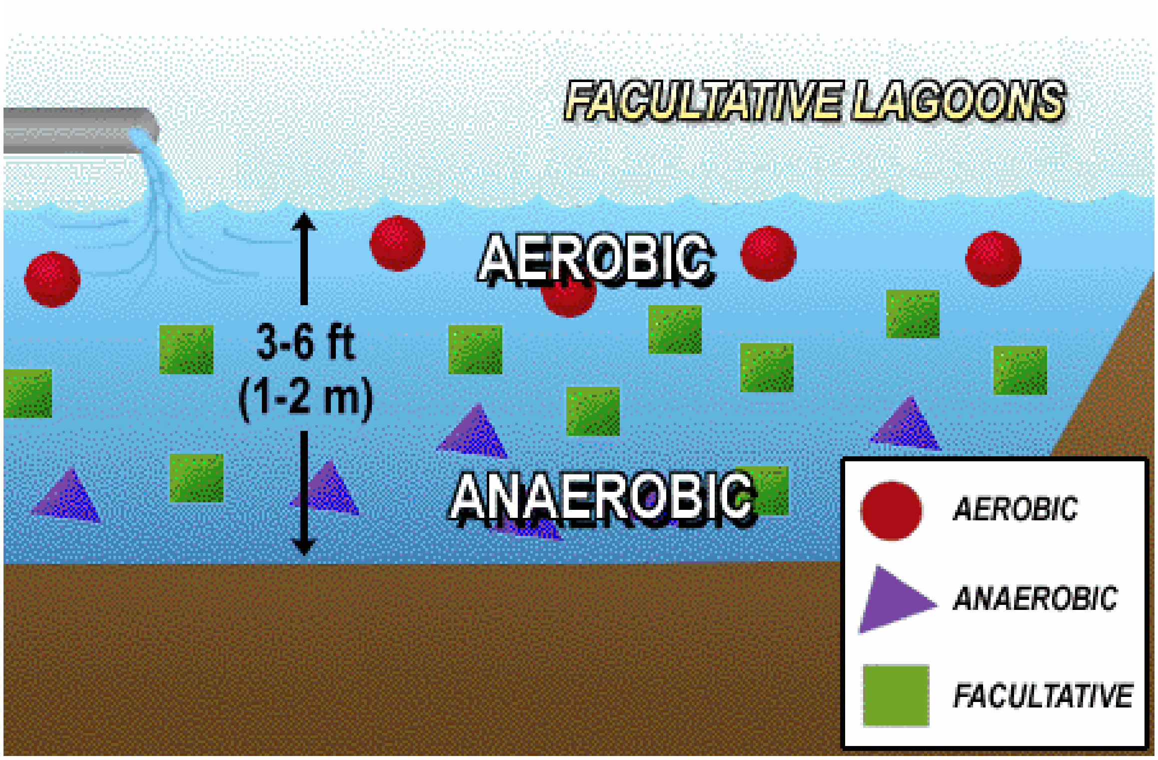

Figure 4.5 Facultative Stabilization Lagoon

Typical Lagoon Design Parameters				
Parameter	Aerobic	Facultative	Anaerobic	Aerated
Size, ac (ha)	< 10 (4) multiples	2-10 (0.8-4) multiples	0.5-2.0 (0.2-0.8)	2-10 (0.8-4) multiples
Operation	Series or Parallel	Series or Parallel	Series	Series or Parallel
Detention time, days	10-40	5-30*	20-50	3-10
Depth, ft (m)	3-4 (1-1.2)	4-8 (1.2-2.4)	8-16 (2.5-5)	6-20 (2-6)
pH	6.5-10.5	6.5-8.5	6.5-7.2	6.5-8.0
Temperature range, °C	0-30	0-50	6-50	0-30
Optimum temperature, °C	20	20	30	20
BOD5 loading, lb/ac/d (kg/ha · d)	54-110 (60-120)	45-160 (50-180)	180-450 (200-500)	--
BOD5 removal, percent	80-95	80-95	50-85	80-95

* 180 days in cold climate

Table 4.1 Design Parameters for Stabilization Lagoons

Lagoon Configurations

Most lagoon systems use more than one lagoon; sometimes, different types of lagoons are used together. Wastewater may also undergo various levels of treatment before reaching the lagoon. In systems with a number of lagoons, the lagoons can be run one after another in a series or all at the same time in parallel (Figure 4.6). If the lagoons are set up in series, wastewater flows from one lagoon to another. A facultative lagoon may follow an aerated lagoon, or it may follow another facultative lagoon. Facultative lagoons may also be used after other types of treatment. For example, when a facultative lagoon is used after secondary treatment, it is called a polishing lagoon. Lagoons used in series produce a final effluent containing comparatively few algae and bacteria. A series operation also reduces short-circuiting. On the other hand, one of the main disadvantages of series operation is the heavy load put on the first lagoon. During periods of heavy loading, the first pond can become anaerobic and produce odors. When lagoons are set up in parallel, the flow is split between them. Parallel lagoons can take heavier loads without becoming anaerobic, but they may not produce as good an effluent quality as a series arrangement. Another advantage of parallel lagoons is that one lagoon can be closed for cleaning or maintenance by diverting the flow to the other lagoon.

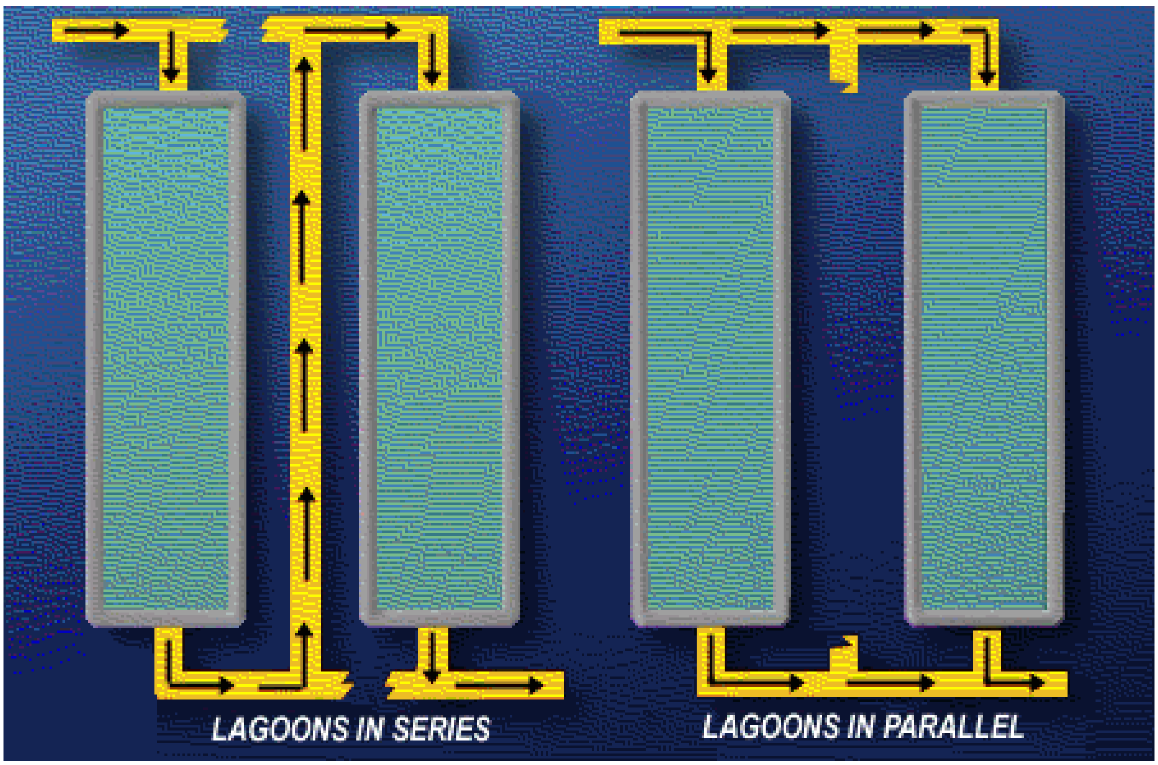

Figure 4.6 Series and Parallel Configurations

Physical Components/Elements of Lagoons

Now that we have introduced the basic functions and types of stabilization lagoons, let us look at the different components and structures related to these treatment systems. The first components we will look at are dikes/berms.

Dikes/berms – Dikes and berms (Figure 4.7) are used for the outer containment of the lagoon. They must be constructed in such a way as to prevent inflow and infiltration from the surrounding environment. Using a bank of well-compacted dirt is used to help prevent leakage. The dikes are often seeded with grass, to form an erosion resistant cover. This grass should be kept cut. Dikes should be constructed so that surface runoff cannot enter the lagoon. Therefore it is necessary that all unwanted vegetation be removed from the lagoon area and compact and secure the lagoon perimeter tightly. Also, dikes and berms must be clear and wide enough, at least 3 m (10 ft) or greater, to allow vehicles access to any area of each lagoon.

Figure 4.7 Stabilization Lagoon Berm

Freeboard – Freeboard (Figure 4.8) is best described as the extra height (or depth) given to the sides of your lagoon to deal with excess flows and large wave patterns. Typically, it is recommended you have at least 0.9 m (3 ft) of freeboard above the maximum normal holding level for your lagoon.

Figure 4.8 Lagoon Freeboard

Slope – Slopes for stabilization lagoons (Figure 4.9) can range anywhere from 3 – 5 (horizontal distance) to 1 (vertical distance). The slope of the lagoon along with the freeboard must be protected from erosion due the natural wave action of the wastewater. Forms of protection for the sides of the lagoon include erosion-resistant soil/vegetation, revetments (stone or rock covering), or wave dissipating implements, such as breakwaters.

Figure 4.9 Revetted Slope of Stabilization Lagoon

Inlet and Outlet Structures – Lagoon inlet structures are designed to provide good distribution at the influent and minimal erosion. Usually, a force main inlet is located on the bottom of the lagoon at least one third of the way down its length. The inlet pipe sticks up from the bottom of the lagoon about 0.3 m (1 ft) above the sludge on the bottom. Gravity inlet structures can also be used and a concrete pad may be included to prevent erosion as noted in Figure 4.10. Typically, a stabilization lagoon will have more than one inlet. It is best if the inlets are placed far apart and wastewater is introduced evenly throughout the lagoon using diffusers. It is also recommended to use baffling when required to ensure even flow distribution and minimize short-circuiting. If your lagoon uses a single inlet, it should be placed as far from the outlet structure as possible.

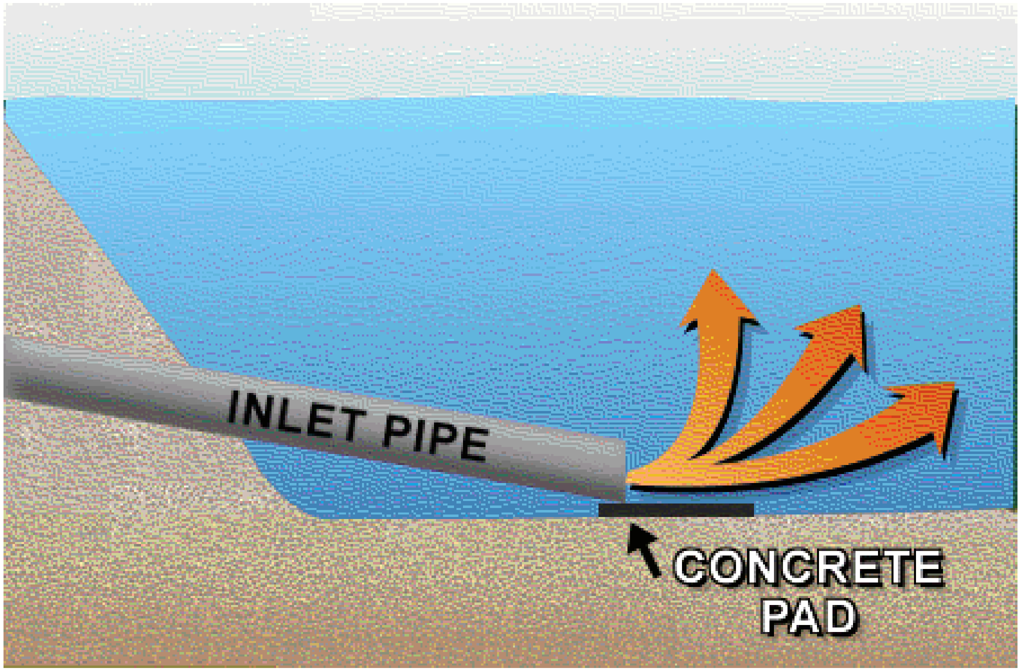

Figure 4.10 Inlet Configuration for Stabilization Lagoon

Outlet structures (Figure 4.11) must be designed to allow treated effluent to leave at an acceptable rate yet not drain the lagoon too quickly and provide overflow control in case of hydraulic overload. Outlet structures must also be valved, slotted, or designed to draw off effluent at varied depths. Regardless of the lagoon's depth, it is preferred if the outlet is able to draw of the top layer of lagoon contents since typically (for aerobic and facultative lagoons) this is the highest quality water. A surface baffle should be placed around the outlet of the lagoon. The baffle keeps floating solids from going out in the effluent. Some lagoons have specially constructed outlets to prevent scum carryover into the effluent. For good treatment results, it is useful if your inlet and outlet are placed in such a way as to promote plug-flow (inlet-to-outlet flow) characteristics in your lagoon. All lagoon structures must be designed to facilitate easy access for repair and upgrade.

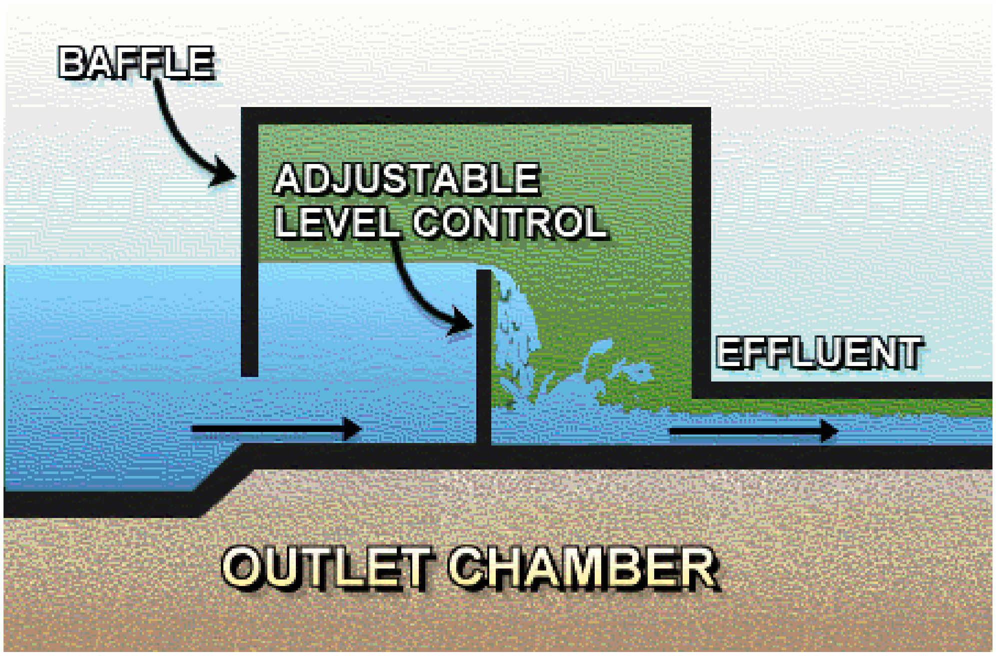

Figure 4.11 Outlet Structure for Stabilization Lagoon

Lagoon Floor – The bottom of a lagoon must be as level as possible and well compacted to avoid seepage of untreated wastes into the soil. If your lagoon is aerated or typically very agitated (wind action), it my be necessary to line or seal the floor of your lagoon. The common choices for floor liners are:

- Rubber or synthetic compound liners;
- chemical or natural sealants; and
- rock or cement lining.

Treatment Efficiency

When wastewater enters a lagoon, the nonsettleable suspended and dissolved organic matter moves around in the lagoon, while the settleable matter falls to the bottom. Let us take a closer look at what happens in a facultative lagoon. If dissolved oxygen is present, the aerobic and facultative bacteria will begin to break down the suspended and dissolved organic matter into carbon dioxide and water. Algae grow in the top 0.3 – 0.6 m (1 – 2 ft), of the facultative lagoon. In the presence of sunlight, algae use carbon dioxide to live and reproduce. As they reproduce, the algae produce more oxygen. In other words, the algae and bacteria supply each other's needs.

A large portion of the oxygen in facultative lagoons comes from algae, although aeration may also result from wind, wave actions and other natural means. The amount of dissolved oxygen in the lagoon will also depend largely on how much sunlight is available. Because algae produce oxygen only in the presence of light, the dissolved oxygen concentration in the lagoon will vary from a high in the late afternoon to a low just before dawn.

You can also expect a reduced dissolved oxygen concentration in cloudy weather and if the weather is cooler. Another possible effect of cloudy weather is a drop in temperature in the top layer in the lagoon. If the top cools so much that the bottom layer is warmer than the top layer, the bottom layer may rise to the surface. This is called lagoon turnover (Figure 4.12). Since anaerobic decomposition takes place at the bottom, lagoon turnover can lead to the release of foul-smelling gases. Lagoon turnover can happen any time the surface of the lagoon becomes cooler than the bottom and can last several weeks.

Figure 4.12 Stabilization Lagoon Turnover

The algae/bacteria relationship (balance) in the lagoon can be upset by toxic wastes as well. Toxic wastes like heavy metals, cyanide, or phenols can enter the lagoon from industrial discharges. This can upset effluent quality and increase the discharge of undesirable material into the receiving waters.

As with any process, the best way to monitor its efficiency is to calculate the removal of primary pollutants such as BOD and suspended solids.

Loading

Toxic wastes can kill algae and bacteria, causing treatment to slow down or stop. It can take about 4 – 8 weeks before enough bacteria develop again to provide effective treatment. High-strength wastes can also upset a lagoon. If very strong wastes are periodically received, the lagoon may become overloaded. With an increase in waste, bacterial action will also increase. More oxygen may be required than that provided by the algae and mixing action. This can result in anaerobic conditions and poor effluent quality.

Over time, sludge slowly builds up on the bottom of a facultative lagoon. Normally, lagoons should be cleaned every ten to twenty years (10 – 20 yr), depending on the amount of grit in the influent.

How much waste can a lagoon handle? A facultative lagoon can treat the wastes of 100 – 200 people for each half-hectare of surface area. In other words, a 2-hectare lagoon would be able to handle the wastewater from 500 to 1000 people. Of course, if you have industrial wastes entering the lagoon, you will have to increase the lagoon size. Industries can discharge high-strength wastewater to lagoons and should be analyzed to determine exactly what load is contributed. You can expect the load to a facultative lagoon to vary during the day and perhaps even with each season. Daily variations will not affect effluent quality because the wastewater stays in the lagoon for quite a while. Seasonal variations, however, can result in periods of low effluent quality.

Detention Times

The usual detention time in facultative lagoons can range anywhere from several days to one month based on the loading and use of supplemental aeration. In these lagoons, the effluent is continuously discharged. Remember that in cool or cloudy weather, the temperature and amount of sunlight reaching the lagoon decrease. One way of compensating for this is to increase the detention time by raising the liquid level in the pond. If the liquid level cannot be raised, then the effluent quality can be poorer in cool cloudy weather than under warmer sunnier conditions. It may be necessary to provide aeration in cases where your lagoon may be oxygen-deprived or deficient for any significant length of time.

In the facultative lagoon, we depend on nature to provide enough dissolved oxygen to keep the lagoon operating properly. In the aerated lagoon, we help nature out by providing additional oxygen to the wastewater. Artificial aeration produces more oxygen than can be supplied by the algae. It also keeps the wastewater in the lagoon mixed, keeping the organics and bacteria in contact with each other. This means aerated lagoons can be designed for shorter detention times, heavier loadings, or both. Some lagoons are designed for aeration, though aeration equipment can also be added to existing lagoons when the loading to the lagoon exceeds its design capacity.

Methods of Aeration

The two most common methods used to get additional oxygen into the lagoon are mechanical aeration and diffused aeration. Mechanical aerators on the surface of the water mix the water and air. The air dissolves in the wastewater and increases the dissolved oxygen level.

To prevent settled sludge and bottom sediments from being disturbed, mechanically aerated lagoons are deeper than conventional nonaerated lagoons. Figure 4.13 shows what happens when a mechanical aerator is used. Diffused-air aeration does not provide as much mixing in lagoons as mechanical aeration. Lagoons can use either coarse-bubble diffusers or fine-bubble diffusers. Air introduced in the bottom of the diffuser rises through the diffuser and is directed around a set of baffles in the tube that breaks up the air into smaller bubbles. Both methods of aeration, mechanical and diffused air, can provide good mixing and oxygen transfer depending on how the system is designed and installed.

Figure 4.13 Aeration and Mixing Provided by Mechanical Aeration

The main advantage of an aerated lagoon is the reduced amount of time that wastewater must stay in the lagoon. This means that an aerated lagoon can handle a much greater load than a nonaerated lagoon. In fact, the loading capacity of aerated lagoons is about 10 times more than that of nonaerated facultative lagoons. Aerated lagoons can be as efficient as nonaerated facultative lagoons. Because aerators create a lot of mixing in the lagoon, solids tend to stay in suspension. The efficiency of an aerated lagoon will depend on how much time is allowed for these solids to settle. Sometimes, a separate settling lagoon is used. There is a way to improve this situation. Suspended solids in an aerated lagoon can be reduced if aerators are put near the influent end of the lagoon, as far away as possible from where the effluent is discharged. Since the influent is warm, this also helps prevent the aerator from icing up in the winter. It is also a good idea to use baffles in an aerated lagoon. Aerated lagoons provide better treatment if they are baffled to prevent wastewater short-circuiting from the lagoon inlet directly to the lagoon outlet.

Some lagoons have a clarifier constructed at the end of the aeration zone. Other systems use separate clarifiers instead. Sludge that settles in the clarifier hopper is removed by an airlift pump. The sludge is returned to the influent end of the process or is wasted to the solids-handling facilities. The mixed liquor solids concentration in the lagoon is maintained between 1 500 and 5 000 mg/L. The clarifiers, whether integral or separated, have surface settling rates in the range of 8100 – 32 600 L/m^2·d (200 – 800 gpd/ft^2) with 16 300 L/m^2·d (400 gpd/ft^2), being the average. Weir overflow rates should be maintained below 407 000 L/m·d (32 800 gpd/ft). These lagoons operate like an extended aeration activated sludge process. They are organically loaded at 0.10 – 0.30 kg BOD/m^3·d (6.2 – 18.7 lb/d/1000 ft^3) of surface area and operate with a hydraulic residence time of 24 to 48 hours. As you can see, these lagoons can treat more wastewater in a shorter period of time than a typical aerated lagoon.

Lagoon Design Differences

A facultative lagoon (i.e., not aerated) is usually 1 – 2 m (3 – 6 ft) deep. An aerated lagoon, on the other hand, is about 2.5 – 5 m (8 – 15 ft) deep. Aerated lagoons are usually deeper than nonaerated lagoons so that mixing does not disturb the sludge on the bottom. Lagoons are usually square or rectangular. The inlet is placed at one end, and the outlet is placed as far away as possible to prevent short-circuiting. Aerated lagoons may have different shapes. They are usually shaped to provide the best mixing. If there is more than one lagoon in the system, the lagoons are set up in series or in parallel, or may be capable of operating either way. Lagoon operation is more flexible if the piping between the lagoons will allow either series or parallel operation and allow one lagoon to be drained while others are still operating.

Other Types of Wastewater Lagoons

There are also three other types of lagoons. A seepage lagoon follows a primary lagoon after biological treatment has taken place. Seepage lagoons are designed so that wastewater leaks or percolates into the soil. These types of lagoons contain sandy soils on the lagoon bottom that allow the wastewater to percolate into the ground. As the wastewater percolates into the ground, solids are captured by the sand and soil, which act as filters. Seepage lagoons require that monitoring wells be constructed around the perimeter to sample the wastewater that may be entering into groundwater. These types of lagoons are not constructed near groundwater wells that are used for potable drinking water.

Aquatic plant lagoons (Figure 4.14) may also be used to treat domestic and industrial wastewater. These lagoons use aquatic plants to achieve specific wastewater treatment and water quality objectives. The principal floating plant species used in aquatic treatment systems include water hyacinth, duckweed, and pennywort. Some systems are designed with submerged aquatic plants, but they will not be discussed here. In aquatic systems used for municipal wastewater, the carbonaceous biochemical oxygen demand (CBOD) and suspended solids (SS) are removed principally by bacterial metabolism and physical sedimentation. In systems used to treat CBOD and SS, the aquatic plants themselves actually treat very little of the wastewater. Their function is to provide components that improve the wastewater treatment capability and/or reliability of their aquatic environment. In aquatic treatment systems designed to remove the nutrients such as nitrogen and phosphorus, plant uptake can contribute to removal, especially where plants are harvested frequently.

Figure 4.14 Common Aquatic Plant Lagoons

Until recently, most of the floating aquatic plant systems used in wastewater treatment have been water hyacinth systems. Water hyacinths are freshwater plants with round, shiny-green leaves and lavender flowers. Water hyacinths grow rapidly on a lagoon, so they must be harvested frequently so that they do not hinder the growth of other aquatic plants in the lagoon. Water hyacinths cannot function in colder climates. Table 4.2 shows the typical design parameters of a water hyacinth aquatic system. Organic loading is the key parameter considered in the design and operation of water hyacinth systems. Typical organic loadings are in the range of 10 – 300 kg/ha·d. If the organic loading is too high, mosquito problems can increase. As shown on the table (Table 4.2), this system is also designed for a hydraulic loading rate of 240 – 3 570 m^3 /ha·d. Another important parameter for this system is the depth of the lagoon, which is typically 0.4 – 1.8 m (1 – 3 ft) deep.

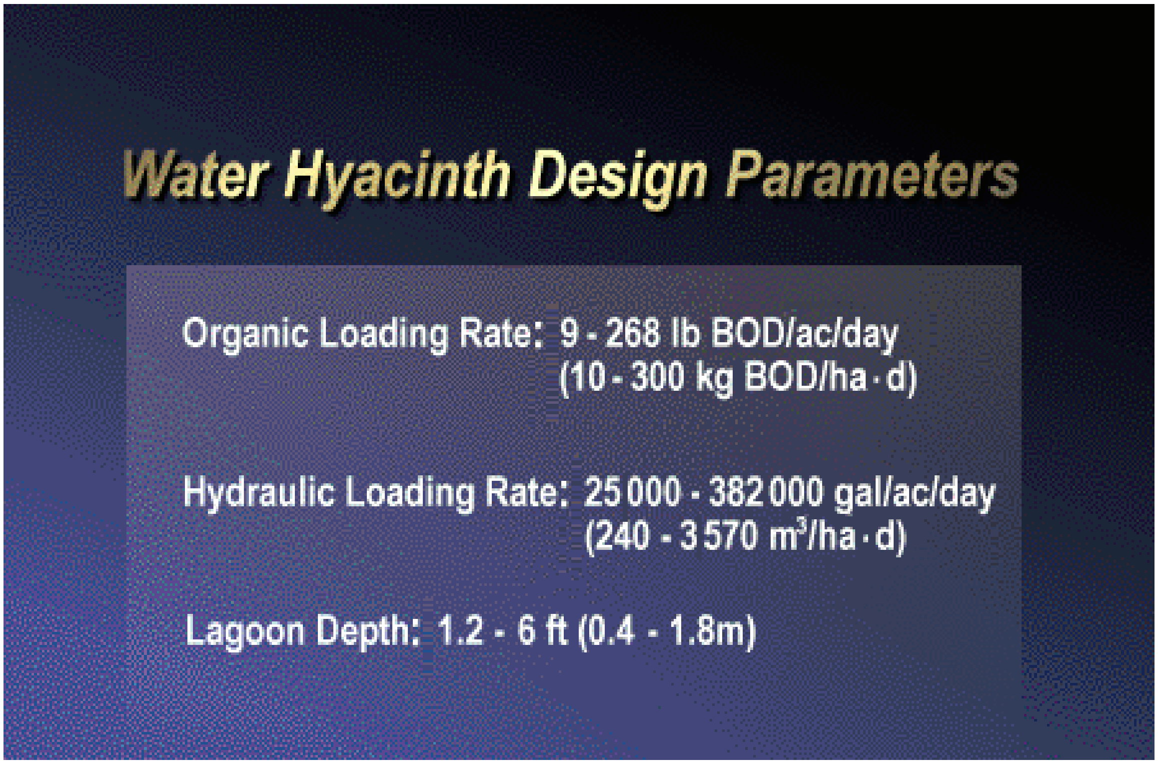

Table 4.2 Typical Design Parameters for Aquatic Plant systems

Duckweed systems are the other aquatic plant lagoon system. Duckweed are small, green freshwater plants with leaves (fronds) 1 – 3 mm (1/8 – 1/2 in) in width. They are fast-growing plants. Aquatic treatment systems employing duckweed have been developed by following the conventional design procedures for facultative lagoons. The advantage of duckweed systems is lower algae concentrations in the effluent. Table 4.3 shows typical design parameters and effluent quality of duckweed systems. For further information on the operation and troubleshooting of aquatic plant systems, operators should refer to the Water Environment Federation's Manual of Practice No. FD-16, *Natural Systems for Wastewater Treatment*.

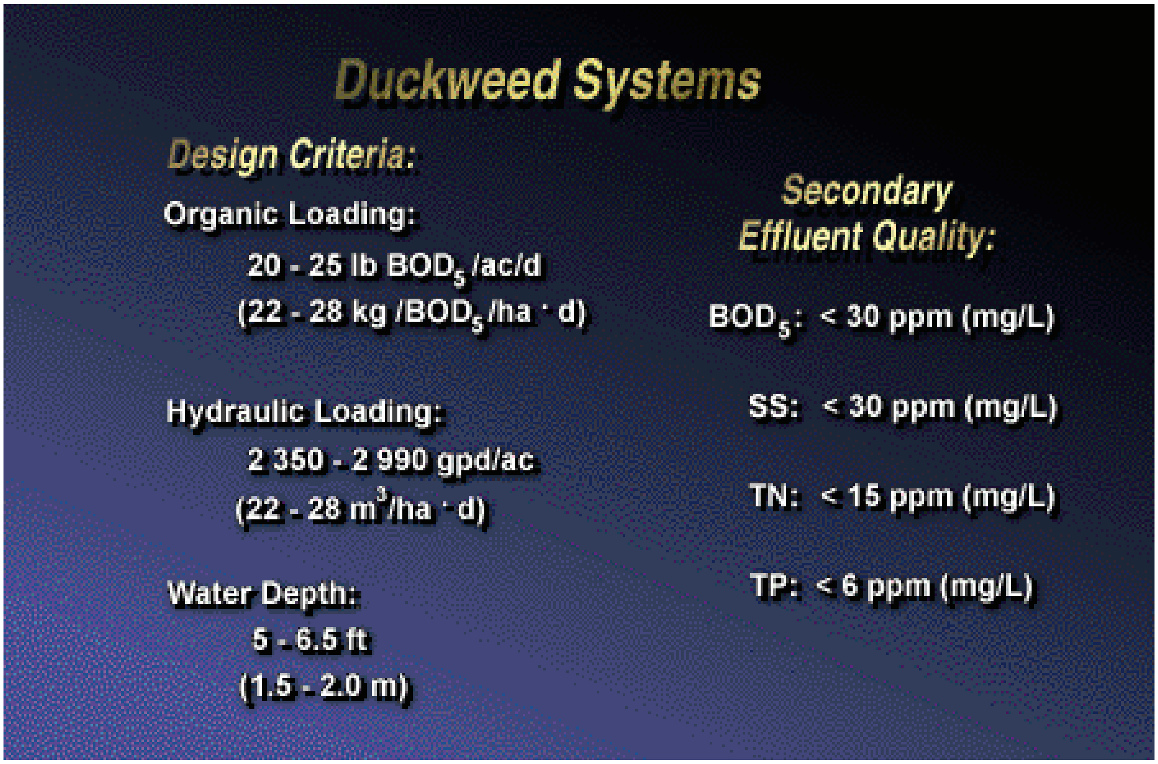

Table 4.3 Duckweed System Design Criteria and Effluent Quality

Safety

Lagoons can be hazardous. Keep people, wildlife, and livestock away from lagoons and construct fences around them. Warning signs should state that the water is nonpotable and that there is no trespassing, swimming, or fishing allowed. Operators must also be aware that lagoons are home to snakes, mosquitoes, spiders, and burrowing animals. Care should be taken to avoid being bitten.

Earthen and lined berms can be slippery when wet and pose a slip hazard. Operators should use lifelines when walking in slippery areas to avoid the drowning hazard of slipping into the basin. Whenever chemicals are used in the lagoon or on the berm or embankment, operators must follow all recommended safety procedures. If the lagoon contains mechanical aerators or blowers, make sure that the equipment is properly LOCKED OUT and TAGGED at the control panel (Figure 4.15) before work is performed on the equipment. Another electrical safety concern is exposed wires, either near or on the berms that feed mechanical equipment. When mowing, use care to avoid cutting wires, and repair any damaged wire immediately. Operators should keep life preservers, life jackets, and a boat with oars next to the lagoon. If an operator has to boat out onto a lagoon, he or she should always wear a life jacket. Operators should never work on or around a lagoon alone. A partner should always be near in case a problem arises.

Figure 4.15 Lockout Tagout at Control Panel

Chapter Quiz

1. The three types of stabilization lagoons include aerobic, anaerobic, and:
   a. Facultative
   b. Anoxic
   c. Heterotrophic
   d. Autotrophic

2. Next to maintaining a DO level in an aerated stabilization lagoon, the most important function of an aerator is to:
   a. Destroy mosquito larvae
   b. Provide mixing
   c. Assist photosynthesis
   d. Prevent buildup of algae and duckweed mats

3. One source of oxygen in an aerobic lagoon is:
   a. Bacteria
   b. Rotifers
   c. Algae
   d. Crustaceans

4. Algae will only survive in the presence of:
   a. Bacteria
   b. Sunlight
   c. Fish
   d. DO

5. In a facultative stabilization lagoon, water depth should be maintained at approximately:
   a. 0.5 to 1 ft (.1 to .3 m)
   b. 1 to 3 ft (.3 to 1 m)
   c. 4 to 8 ft (1.2 to 2.4 m)
   d. 8 to 16 ft (2.5 to 5 m)

Chapter Quiz Answers

Question 1

Answer is: “a”
Reference: Page 4-3
Immediate Feedback: The bacteria perform the treatment in a lagoon and the amount of dissolved oxygen available determines the kind of bacterial action that will take place. This means that there are different kinds of waste stabilization lagoons: aerobic, anaerobic, and facultative.

Question 2

Answer is: “b”
Reference: Page 4-12
Immediate Feedback: Aerators create a lot of mixing in the lagoon. The loading capacity of aerated lagoons is about 10 times more than that of nonaerated facultative lagoons.

Question 3

Answer is: “c”
Reference: Page 4-2
Immediate Feedback: The algae produce the oxygen needed by the bacteria, and the bacteria in turn produce the carbon dioxide needed by the algae.

Question 4

Answer is: “b”
Reference: Page 4-2
Immediate Feedback: Algae are plants, so they need food, carbon dioxide, water, and sunlight to grow. In sunlight, the algae grow and produce oxygen, which dissolves in the water.

Question 5

Answer is: “c”
Reference: Page 4-6, Table 4.1
Immediate Feedback: The typical facultative lagoon is designed to a depth ranging between 4 and 8 feet.