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How a Lagoon Works

For Livestock Wastewater Treatment

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What Are Lagoon Systems?

Lagoon systems are a series of one or two pond-like structures designed to treat livestock wastewater for a specified period of time. They are lined with clay or a synthetic liner to prevent leakage into the soil and ultimately groundwater or other water sources. Lagoon systems use biological, physical, and chemical processes to treat the wastewater during its storage period before dispersal onto crops, pasture ground or other types of land. Most of the treatment occurs naturally by anaerobic or aerobic bacteria, depending on the design of the lagoon system. Where land is scarce, mechanical aeration makes treatment more efficient in a smaller area. Lagoon systems are designed to fit the specific construction site as well as the amount and type of wastewater to be treated.

Various Types and How They Work

Anaerobic Lagoons

Anaerobic lagoons utilize bacteria in the absence of oxygen to treat wastewater. These lagoons are used as a single pond system or as the first pond in a series design. Requiring relatively small design volumes, these lagoons are very deep and work similarly to septic tanks. Over a 20 to 50 day period wastewater solids separate into layers, with oils and floating materials on top and heavy sludge on the bottom. The top layer seals oxygen out of the lagoon system, providing the anaerobic conditions for bacteria to treat the wastewater. The bottom sludge layer, similar to a septic tank, must be removed periodically. Wastewater leaving an anaerobic lagoon often requires further treatment either by connected aerobic lagoons or by chemical or physical purification techniques. Odor can be a problem with anaerobic lagoons, but can be virtually eliminated with proper management. Anaerobic lagoons are good candidates for methane or biogas capture to run on-farm energy generating plants.

Aerobic Lagoons

Aerobic describes the presence of dissolved oxygen throughout the depth of the lagoon. Aerobic lagoons can be either naturally aerated or mechanically aerated. In order to allow oxygen to penetrate the entire lagoon, aerobic lagoons tend to be very shallow and consequently require much more land area than other types of lagoons. However, if properly designed and maintained, an aerobic lagoon can treat wastewater more quickly than all other lagoon types. Aerobic lagoons also produce fewer odors than anaerobic lagoons. Aerobic lagoons are best suited for warm, sunny climates so as to avoid freezing. Because of the shallow nature of aerobic lagoons, special care needs to be taken to avoid weeds and grass growth on the bottom of the lagoon. Often the bottoms are paved or lined with materials to prevent weed growth. Occasionally the wastewater in an aerobic lagoon needs to be mixed to allow additional sunlight and to break up algae clumps that may block the oxygen and sunlight required for the natural treatment process.

Naturally-Aerobic Lagoons

Naturally-aerobic lagoons do not use a mechanical aeration system, but rather rely on oxygen from the atmosphere or from photosynthesis by algae to maintain aerobic conditions. Naturally-aerobic lagoons must be shallow, typically only 1 to 2 feet deep and no more than 5 to 6 feet (Zhang, 2001). The required design volume for a naturally aerobic lagoon is typically four to five times that of an anaerobic lagoon. The land area required to meet the design volume and shallow depth requirements make naturally-aerated lagoons generally impractical for farm use (Jones, 1999).

Mechanically-Aerated Lagoons

Mechanically-aerated lagoons use an aeration system to add oxygen to the lagoon and mix the contents thereby increasing the degree of aeration. A power source is needed to operate the aeration system. Some operators use solar or wind power. By aerating a lagoon system one can significantly decrease the amount of land required for a lagoon and still receive the benefits of a full or partial aerobic lagoon. The required design volume for a mechanically aerated lagoon is about half of an anaerobic lagoon. Depending on the lagoon depth and the extent of aeration, the lagoon can work as a combination of both an anaerobic and an aerobic lagoon (Jones, 1999).

Facultative

Facultative lagoons and aerated lagoons operate in a similar manner and have many of the same benefits. Facultative lagoons use a combination of both aerobic and anaerobic conditions to treat wastewater, but facultative lagoons do not require the use of an aeration system. The top layer, which is exposed to wind agitation, sun, and contains the most oxygen, is the aerobic zone. The middle layer is called the facultative zone where, depending on the climate, both conditions are present to some degree. The anaerobic zone is at the bottom of the lagoon and includes the layer of sludge that accumulates there. Since the aerobic layer is on top, facultative lagoons minimize odor emissions produced by the lower layers. Wind and sun are both important for the processes occurring in a facultative lagoon because they provide oxygen, energy for photosynthesis, and affect the hydraulic flow pattern of the wastewater (Pfost and Fulhage, 2007).

Operation and Maintenance

Practical Operation and Design

Figure 1 presents a simple overview of a single-stage anaerobic lagoon and illustrates operation, design, and maintenance concepts. No secondary treatment takes place in a single-stage lagoon.

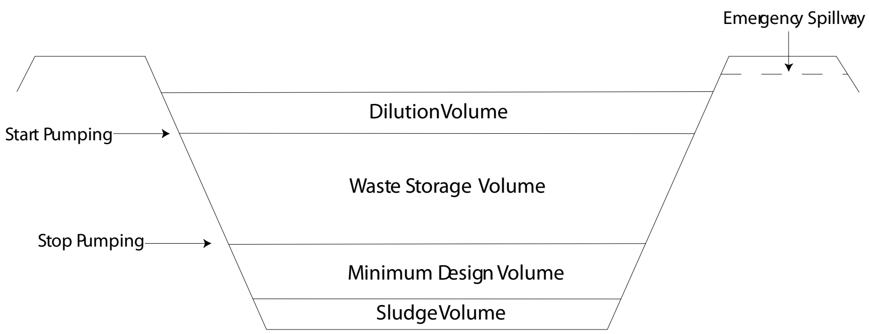

Figure 1. Single-stage anaerobic lagoon cross-section

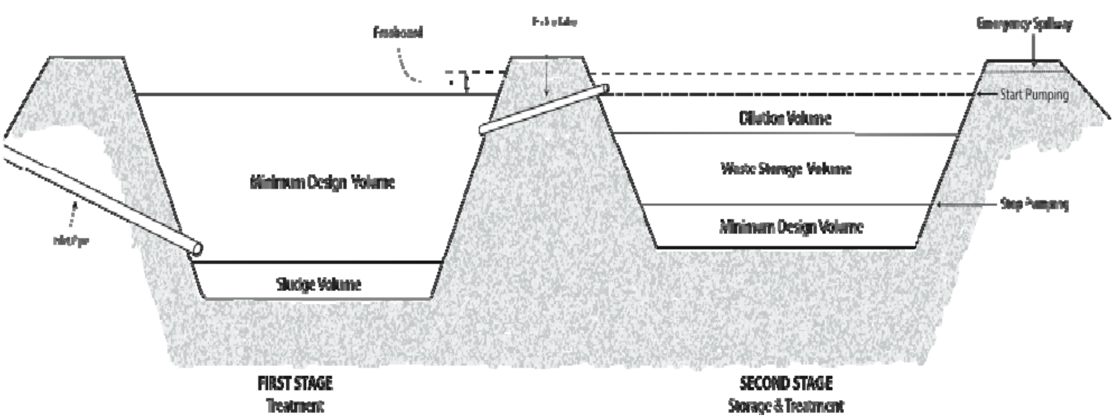

Figure 2. Two-stage anaerobic lagoon cross-section

In a two-stage lagoon (Figure 2), primary treatment takes place in the first stage or cell. The effluent is then transferred to the secondary cell where it undergoes further treatment through bacterial action and oxidation. Odors are controlled better, and the possibility of disease transmission is reduced, when using a two-stage lagoon. Specific design and operation guidelines can be obtained in detail from the reference source “Design and Operation of Livestock Waste Lagoons” by Don Jones of Purdue University as well as other sources. Producers should consult with local authorities to determine the regulations and requirements for their area.

General Maintenance

There are several key components to the general maintenance of a lagoon. First is the loading and dilution of animal waste into the lagoon. Specific loading schedules for lagoons must be designed to fit the lagoon capacity and producer requirements. If the correct population of microorganisms is not developed during loading, it can take years to achieve. The important thing to remember is that when loading animal waste, an equal amount of water must be added to the lagoon to provide adequate conditions for treatment and management of odors (Pfost and Fulhage, 2007).

Second is the discharge schedule of the lagoon. Discharging a lagoon involves emptying a portion of the treated wastewater to provide extra volume for treating additional waste. As illustrated in Figure 1, all lagoons have a minimum design volume, which depends on the type and total volume of the lagoon. When discharging a lagoon, producers must stop discharging when the wastewater level reaches the minimum design volume. The minimum design volume helps manage lagoon odors and maintains conditions required for maximum productivity of the microorganisms involved in wastewater treatment. Odor release can be a problem when lagoons with crusts are drawn down.

Third is monitoring sludge buildup and preparing for its removal. Especially in facultative and anaerobic lagoons, the wastewater treatment time allows for the separation of animal waste into distinct layers including a heavy layer of sludge at the bottom of the lagoon. Well designed and maintained lagoons can go 5 to 10 years without sludge removal (National Small Flows Clearinghouse, 2007). Not monitoring the accumulation of sludge frequently (at least yearly) can severely limit the overall volume of the lagoon and effective wastewater treatment.

Likewise, scum and other objects should be removed from the surface of aerobic lagoons to prevent odors and clogging of inlet and outlet structures. The crust on an anaerobic lagoon should be maintained to prevent odor emissions, and maintain more uniform temperatures and anaerobic conditions. If the thickness of the crust is greater than 12 inches, it should be broken up and removed (ASABE, 2010).

Odor Control

Odor problems usually occur in a lagoon due to lack of maintenance, algal blooms, anaerobic conditions, and turnover of lagoon contents after a freeze. If odors are severe the lagoon can be treated with lime and other chemicals, but treatment is costly and inefficient. Excessive odors are usually caused by inadequate dilution, or over-loading of the lagoon. When over-loading the lagoon is a consistent problem, aeration systems should be considered to increase waste treatment volume while minimizing odors.

Algae

Algae are visual indicators of a lagoon’s overall health. Green algae are present in healthy aerobic lagoons and facilitate wastewater treatment. Blue-green, filamentous algae are undesirable in a lagoon because they clump and block sunlight. A bright rich green color is optimal for facultative lagoons; whereas, gray, black, or purple is indicative of anaerobic conditions (National Small Flows Clearinghouse, 2007). Occasionally after cloudy weather or abrupt temperature changes, algae can multiply quickly and die-off; this matted algae should be broken up or removed.

Weeds, Long Grass, Erosion

Weeds along the interior banks and throughout the lagoon surface “short-circuit” the flow of the lagoon creating dead spots resulting in inadequate treatment of wastewater. In addition to breaking up the physical flow of the lagoon, weeds and long grass provide breeding areas for insects, block wind, provide food for burrowing animals, and trap trash and scum. Mowing around the lagoon and removing surface weeds with a boat or rake prevents problems caused by weeds and long grass. Eliminating weeds and grass often prevents erosion by discouraging the presence of burrowing animals. If erosion due to animals is a problem, alternately raising and lowering water levels can drive out muskrats and other rodents, or the animals can be trapped and relocated.

Advantages and Disadvantages

Advantages of Lagoons

- Compared to other liquid waste handling systems, lagoons are relatively inexpensive to design and build
- Relatively simple to operate and maintain.
- Effluent can be reused for waste removal in flush-type waste handling systems
- Effluent can be used for irrigation water

Disadvantages of Lagoons

- Require more land than other treatment methods
- Less efficient in cold climates and may require longer retention times
- Odor can be problematic, especially during spring thaw in cold climates
- Significant nitrogen loss occurs, reducing the fertilizer value

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