

# **Aerobic Treatment**

Prepared by Jun Zhu, Extension Engineer

## **1. What is aerobic treatment?**

Aerobic treatment is a biological process, the principle of which is the use of free or dissolved oxygen by microorganisms (aerobes) in the degradation of organic wastes. Since oxygen is available to working aerobes as an electron acceptor, the biodegradation process can be significantly accelerated, leading to increased throughput capacity of a treatment system.

## **2. What are the advantages of using aerobic treatment?**

Aerobic treatment has many advantages including: 1) minimum odor when properly loaded and maintained; 2) large biochemical oxygen demand (BOD) removals providing a good quality effluent; 3) high rate treatment allowing smaller scale systems, e.g., less land required; 4) the final discharge may contain dissolved oxygen which reduces the immediate oxygen demand on a receiving water; and 5) the aerobic environment eliminates many pathogens present in agricultural wastes.

## **3. What are the disadvantages of using aerobic treatment?**

The main disadvantage of aerobic treatment is the energy cost of aeration at an adequate rate to maintain the dissolved oxygen levels needed to maintain aerobic conditions in the treated wastewater for aerobic growth. In addition, some organics cannot be efficiently decomposed aerobically. These biologically non-reactive components mainly composed of insoluble materials can account for up to 70% of the chemical oxygen demand (COD). Another issue may rest with the fast production of biomass (sludge buildup) due to active aerobic growth powered by a sufficient oxygen supply by aeration, potentially leading to reduction in storage capacity of lagoons and/or ponds.

## **4. What is the minimum dissolved oxygen level that has to be maintained for odor control of animal manure?**

In general, a dissolved oxygen level equal to 1/3 to 1/2 the biochemical oxygen demand (BOD) load is recommended for odor control. However, some reports from lab studies showed that maintaining a dissolved oxygen level of 0.5 mg/L in the treated liquid was sufficient to achieve satisfactory odor control. However, aeration at this low rate usually cannot efficiently convert ammonia to nitrate, thus likely causing high aerial emissions of ammonia.

## **5. What is the total oxygen requirement for stabilizing animal wastes?**

The total amount of oxygen required in the aeration process depends upon the total demand of the microorganisms oxidizing the waste and can be estimated based on these parameters, i.e., biochemical oxygen demand satisfied, ammonia-nitrogen oxidized, oxidized nitrogen denitrified, and the dissolved oxygen for microbial growth.

## **6. How long does it take to remove odors from manure with aeration?**

There is no straight answer to this question because it depends on a number of factors, such as the aeration level and the characteristics of the manure. One study reported that by maintaining a dissolved oxygen level between 1-2 mg/L, 3 days of aeration could result in an odor-free storage of

365 days for manure with total solids (TS) content  $\leq 1.5\%$ , but only 10-75 days for manure with TS ranging from 3.0 to 4.5%. Of course, if the aeration level is lower than 1-2 mg/L, the aeration time needs to be increased accordingly to achieve the same treatment results.

**7. What is “aeration efficiency” and how is it used?**

“Aeration efficiency” is a technical term measuring the oxygen transfer capability of a particular aerator or aeration system. When evaluating different aerators using the standard clean water test, the ability of each aerator in bringing the oxygen in the air into the water is judged by the amount (kg) of oxygen dissolved in the water by the aerator in consideration of the operating time (hour) and the pump size (horsepower). The common unit for aeration efficiency include: kg (O<sub>2</sub>)/kWh and lbs (O<sub>2</sub>)/hp-h. This information usually is provided by the equipment vendors or manufacturers. Obviously, the higher the aeration efficiency, the more efficient the aeration system will be.

**8. Do aerators perform the same in water and animal manure?**

No. Since all aerators are evaluated using clear water tests by the manufacturers, their performance in terms of aeration efficiency in wastewaters other than clean water will normally be discounted due to the different characteristics in the wastewaters. The extent of efficiency reduction varies with the type of wastewater. For instance, for swine manure, a reduction up to 30% in aeration efficiency is not uncommon. Therefore, the aeration efficiency of different aerators in different wastewaters needs to be determined experimentally in addition to the clean water results.

**9. How much does manure solids content affect aeration efficiency?**

Manure total solids content has a significant impact on the aeration efficiency of aerators. A study showed that when the manure total solids content increased from 0.5 to 4.0%, it led to a reduction in the oxygen transfer coefficient (OTC) by 75% for the tested aerator. This means that the OTC in manure at 4% solids is reduced to about 1/4 the level of efficiency of what it would be in manure at 0.5% total solids level. The oxygen transfer coefficient is a key parameter measured in clean water tests, based on which the aeration efficiency is calculated. As such, a reduction in OTC will linearly cause a reduction in aeration efficiency.

**10. Are there any other techniques than solid/liquid separation to improve aeration efficiency?**

Yes. As discussed early, fresh swine manure contains a large portion of slowly biodegradable organic substances that are not decomposed well during the early stage of aeration. However, if this portion of material undergoes a short anaerobic treatment, a substantial part of it can be broken down to readily available nutrients for aerobes in the subsequent aeration treatment. A Michigan study indicated that using three days of anaerobic preconditioning of swine manure could cut the aeration time in half later.

**11. Why is it still likely for aerated manure to produce odor during post-aeration storage?**

Unless the manure is thoroughly stabilized by the aeration treatment, which means that all the biodegradable organic materials in the manure are destroyed, odor can still be generated during storage after aeration. This is because short-term aeration normally destroys only the most readily biodegradable organic compounds without much impact on the substrates that are relatively slowly degradable during aeration and become the major source for odor production in the post-aeration storage period.

**12. How does the size of farm affect the choice of manure management systems for odor control?**

This is a good question because sometimes using only one technique in manure treatment may not be sufficient in controlling odor emission during the post-treatment storage. A Michigan study reported that the herd size (pigs) was observed to have an impact on the selection of manure treatment system and the treatment cost. For slurry from a small herd (<2000 head) and for a short storage period (~5 days), the cost of aerobic treatment of raw slurry is lower than other treatments when the slurry has a total solids (TS) content less than 4.5%. If > 4.5%, separation before aeration produces the cheapest control of odors. For 30-day storage or more, separation before aeration is always the cheapest for slurries with more than 3.0% TS regardless of herd size. For a large herd (8000 head), separation before aeration to produce slurry that is inoffensive for 30 days of storage is the cheapest method at all TS levels.

**13. Can we aerate animal wastewater lagoons naturally?**

Yes, you can. But you need to be aware of the limitations of natural aeration. Natural aeration basically relies on oxygen from the atmosphere that enters the lagoon liquid by diffusion and/or by algae using waste nutrients and sun energy to produce oxygen by photosynthesis. The oxygen input by diffusion is aided by turbulent conditions while the algal contribution is influenced by sunlight, nutrient levels and other factors controlling photosynthesis. Obviously, the aeration treatment will not work without either wind causing turbulence in the lagoon liquid or sunlight necessary for photosynthesis. These factors cannot be managerially controlled. In addition, the low efficiency in entrapping oxygen into the liquid by natural aeration requires a low loading rate. And the limited sunlight penetration will translate to a significant increase in lagoon surface area because it has to be shallow. Therefore, using natural aeration in treating animal wastewater is scant.

**14. How about mechanical aeration?**

In mechanically aerated lagoons, oxygen is furnished by some mechanism that beats air into the liquid or exposes more liquid surface area to the air with a portion of the oxygen dissolving during the process. Therefore, the mechanically aerated lagoon is not dependent on natural aeration, wind, or algae growth and can provide more uniform and efficient treatment than a naturally aerated lagoon.

**15. How is mechanical aeration used in aerating lagoons?**

There are usually two ways to design and operate aeration systems for lagoons. One is to accomplish complete aerobic waste treatment, normally prior to final discharge. The other is to partially aerate to provide odor control, but not completely stabilize the waste. For agricultural applications, complete aeration in most cases is financially unjustifiable because of the excessive energy cost, and is unnecessary neither because seldom will the treated wastewater be directly discharged to surface water bodies such as rivers, creeks, and lakes. Therefore, partial aeration of animal manure lagoons for odor control is the most common purpose in agricultural applications.

**16. Do I have to run aeration continuously?**

It depends on the organic loading rate (biochemical oxygen demand) to the lagoon and the aeration capacity of the aeration system used. If the loading rate is lower than the oxygen injection rate, an intermittent aeration mode can be adopted to save energy, which can be controlled by the dissolved oxygen (DO) level in the liquid. It also depends on what level of DO you would like to maintain in the liquid. For instance, if you only need to maintain a minimum DO concentration of 0.5 mg/L in the

liquid to control odor, you may significantly cut back the running time of the aeration system if it is designed to provide sufficient oxygen for complete aeration treatment.

**17. What is surface aeration?**

Surface aeration is a typical type of partial aeration in which only the top liquid in a lagoon receives the aeration treatment, primarily aiming at controlling odor emissions from the lagoon. Because it is a partial aeration, the energy consumption is substantially reduced (usually only 1/5 to 1/10 of the full aeration).

**18. Can surface aeration control odor?**

Principally, yes. The surface aerated layer functions as a biological cover preventing the odorous compounds in the lagoon from escaping to the atmosphere, thus reducing odor emissions. In the last twenty some years, although surface aeration has been extensively studied in lab-scale settings that panned out extremely encouraging findings in terms of controlling odors, little has been done to take this technology to the next level, i.e., field application. Thanks to the funding provided by the USDA/NRI Air Quality Program, a study by the University of Minnesota researchers on using surface aeration technique to control odors from open manure storages is underway and hopefully by the end of the study, an affordable and effective surface aeration technique will become available to animal producers.

**19. What are the types of aerators available for consideration?**

There are numerous aerators in the market currently, which can be categorized into the following five types based on the way of operation, i.e., a) compressed air, b) mechanical surface, c) mechanical subsurface, d) combined compressed air/mechanical, and e) pumped liquid. Within each type, the actual design of an aerator for a particular application can vary widely. Measurements made in other liquids may be of little use because aerator characteristics can change significantly between different liquids. It is therefore recommended that producers who are considering using aeration to control odor consult with aeration technology professionals to determine the type, size, and management of an aeration system for their applications.