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Manure Storage & Handling—Aeration Overview

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AMPAT Air Management Practices Assessment Tool

Manure Storage & Handling—Aeration Overview

Application: used to reduce ammonia, methane, and odor emissions from manure storages

Pros

- Proven technology from municipal wastewater treatment facilities.
- Extremely effective for odor control.

Cons

- Energy intensive to provide sufficient aeration.
- Maintenance and performance of the system during winter months.
- Typically cause loss of nitrogen.
- Higher sludge generation in the storage.

Description

Aeration is the process of mixing air into the manure to promote the growth of aerobic bacteria. Oxygen must be supplied either naturally, mechanically through mixing, or using oxygen diffusion systems. Aeration techniques have been used by municipal wastewater treatment facilities for years to stabilize waste and provide odor control. This technology can also provide dramatic odor reduction from livestock waste management facilities, but it has not found frequent application in agriculture due to the intensive energy use and resulting added utility costs.

In this system, air is added to the manure to provide oxygen and create an aerobic environment in the manure to sustain aerobic microbes instead of anaerobic microbes. The advantage of this is that oxygenated manure has a microbial environment that leads to more intensive breakdown of organic, odor causing compounds. Aeration provides oxygen which switches the environment from anaerobic to aerobic and with it a switch in bacteria from anaerobic bacteria that produce carbon dioxide, ammonia, sulfur-compounds, volatile organic compounds, and methane, to aerobic bacteria. The aerobic environment allows microorganisms to quickly metabolize the organic acids, aldehydes, alcohols, volatile amines, phenols, indoles, and skatols, which are responsible for the most offensive manure odors. These aerobic microorganisms consume these compounds, while reacting with oxygen to obtain energy, and in so doing convert them to odorless substances, such as carbon dioxide and water. Complete aeration will also convert nitrogen from ammonia to nitrate and sulfur (often as hydrogen sulfide) to sulfate which reduces the manure odor potential further; however,



Figure 1. Surface aeration units and mixers in a concrete swine manure storage.



Figure 2. A floating aeration unit. In this unit, air and manure are mixed in a vortex as it passes through the pump impeller. Discharge is below the fluid surface to encourage oxygen transfer.



Figure 3. A down-draft aeration unit with a 5 HP, 3-phase motor that mechanically mixes and aerates the manure in lagoons or storage tanks.

this level of aeration is usually not economically justifiable in manure systems.

Many techniques have been developed for aerating swine manure, with differences in techniques driven by how complete the aeration is achieved and the completeness of the aeration treatment. Complete aeration treatments can effectively eliminate odor, but require significant energy consumption. Aeration rate requirements to stabilize the manure can be estimated based on the biochemical oxygen demand (BOD) of the manure, with a general rule of thumb being to supply 1.5-2x times the amount of oxygen required based on the biochemical oxygen demand. As a reference, a 150-lb pig excretes about 0.5 lb of BOD per day, so a 4000 head facility would need to provide about 3000-4000 lbs of oxygen to the manure per day. Commercial-size surface aerators typically range in efficiency from about 2 to 4 lbs O₂/hp-hr, so about 1000 kW-hours would be needed to aerate the manure. Assuming an electric cost of \$0.07 per kW-hour, the operating expense would be about \$25,000 per year, or \$6 per pig-space. Providing this amount of oxygen to the manure can be expensive. Treatments that remove organic material (solid-liquid separation) prior to aeration can reduce the aeration requirement and the energy use as a result energy use.

Alternatively, rather than treating the manure for complete stabilization, the manure can be partially aerated. This will provide some stabilization and odor control, but not to the level achieved with complete aeration. The idea behind this is that short-term aeration systems attempt to strip highly volatile odorous compounds from the manure just prior to times when odor concerns might be anticipated. For example, short term aeration treatment (3 to 5 days) prior to land application in areas that are near neighbors. The minimum aeration requirements for acceptable odor control depend on the farm size, manure characteristics, and odor control needs of the farm, so no universal rule exists, but as a first estimate aerating to satisfy 1/3 to 1/2 of the manures BOD is reasonable. This reduces the cost to about \$2 to \$3 per pig space.

Various methods of achieving aeration exist, but mechanical surface aerators tend to be the most common in agricultural settings. Other methods include compressed air aerators, liquid pumps, and aerobic vessel reactors.

Strategies for acidifying the manure that have been attempted include dietary practices used to acidify urine (such as

adding phosphoric acid to the diets or adding small amounts of fiber to the diet which reduces manure pH), dosing the manure with strong acids (often sulfuric acid or nitric acid), or weaker fermentable acids (lactic acid). Modifying dietary practices can be effective at acidifying manure at excretion, but during storage the manure pH tends to increase and as a result effectiveness at reducing ammonia loss decreases. Strategies of dosing acid to the manure can be more effective at maintaining acidic pHs. Recent works tends to suggest that adding about 33 to 50 lbs of concentrated sulfuric acid (H₂SO₄) per 1000 gallons pig slurry reduces the slurry pH to between 5.5 and 6.0. The addition of these strong acids to manure slurries will typically cause a large amount of carbon dioxide to off-gas immediately after addition of the acid, which may cause some temporary foaming.

In poultry systems alum or other litter amendment are often applied between flocks of birds. Numerous application methods have been tried including de-caking machines as well as fertilizer, manure, and drop spreaders for granulated products. If using granulated alum, it should be mixed into the litter prior to placing birds. Liquid alum is normally applied by certified applicators. The use of acidification in slurry manure storage systems is not as developed, but research has tended to indicate it can be effective; however, it is thought that acidification may cause the emission of more hydrogen sulfide.

Effectiveness

Component	Effectiveness	Notes
NH ₃	-20 to 70%	Aeration will cause loss of some ammonia, but complete aeration will stop future volatilization
H ₂ S	-10 to 70%	Complete aeration will stop further volatilization, but some lost during aeration process
Odor	50 to 90%	Very effective for odor control, level of performance dependent on the degree of aeration
Particulate Matter	—	—
Volatile Organic Compounds (VOC)	—	—
Greenhouse gases	—	Undocumented, but expected to significantly reduce methane emissions and increase N ₂ O emissions
Cost	\$\$	Generally a high utility cost

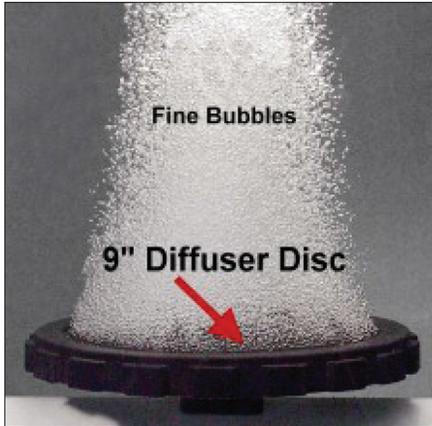


Figure 4. A diffuser disc for aeration. Discs have a rubber member with small slits to encourage formation of fine bubbles to encourage oxygen transfer to the manure.

- <http://www.extension.org/pages/38771/how-much-aeration-is-required-to-substantially-reduce-odor-in-a-storage-pond-or-lagoon>
- <http://www.omafr.gov.on.ca/english/engineer/facts/04-033.pdf>

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Cost Considerations

Average annual utility costs to control odor from swine finishing operation is about \$3 per pig space. Estimated costs of aeration systems range from \$1 to \$6 per pig. Floating aerators range in price from \$3,000 to 10,000 per unit.

More Information

- <http://www.extension.org/pages/24012/a-surface-aeration-unit-for-odor-control-from-liquid-swine-manure-storage-facilities>

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