Methods and Practices to Reduce Odor from Swine Facilities

Albert J. Heber and Don J. Jones, Department of Agricultural and Biological Engineering
Alan L. Sutton, Department of Animal Sciences

Odors, emitted mainly from manure but also from decaying feed and carcasses, are a major concern of the pork industry. Larger swine facilities and increased public concern over agricultural odors have resulted in a number of well-published conflicts in recent years. Purdue and other universities are addressing these problems through research and educational programs.

This publication describes all known methods and practices that may reduce odor nuisance from swine production units. They are categorized as "feasible methods" or "methods under research and development." The feasible methods are those which have been shown to be both economically and technically feasible for some farms. Methods under research and development are currently generally not feasible for pork production either economically or technically or both.

When deciding which individual measures to use to reduce odors from swine facilities, producers should take care that measures they carry out in one part of the operation do not increase odor production from the overall operation. For example, while pull-plug pits drained to the outside may reduce building odor emission, overall odor production from the operation could increase if the drained manure is not properly handled, stored, and treated.

Feasible Methods

Site Selection

• In selecting a site, consider distance to nearby homes and public facilities based on number and weight of pigs, odor abatement practices used, facility design and management, prevailing wind direction, topography, and land use.

• You can use an odor setback guideline under development at Purdue to calculate appropriate setbacks. If current facilities appear too close to neighboring residences, use best management practices described in this publication or other odor-reduction methods to reduce the odor impact of the facility on the neighbors. Table 1 provides the shortest and longest distances estimated by the odor setback guideline for gestation sows and nursery pigs. These recommended distances were calculated with the maximum factors for building design and management, odor abatement, and land use. The effects of wind frequency and surrounding topography on atmospheric dilution are shown as the extreme cases of worst and best dispersion. Actual distances will depend on site-specific wind characteristics. The model provides setback distances in eight directions from the facility.

Table 1. Recommended Setback Distances Between Swine Buildings and Residential Areas

Number of Head	Gestating Sows (best/worst dispersion) ft	Nursery Pigs (best/worst dispersion) ft
100	283/471	156/259
500	632/1054	348/580
1000	894/1491	492/821
2000	1265/2108	696/1160
3000	1549/2582	853/1421
4000	1789/2981	985/1641
5000	2000/3333	1101/1835
7500	2449/4082	1348/2247
10000	2829/4713	1557/2595

Buildings

• If constructing new facilities, consider a system that allows routine removal of waste (less than every seven days) from the building to a covered pit or well-managed lagoon. You can use flush, pit recharge, or scrape systems.

• If remodeling existing facilities, remember that smooth interior surfaces aid cleaning and slatted floors tend to stay drier than solid floors. Also, underfloor ventilation promotes drying of the floor.

• Agitate and empty pits only when favorable wind conditions prevail (blowing away from neighbors).

• Clean the building after each group of pigs.

• Keep at least 2 inches of water on the floor of open or underfloor manure collection gutters and pits.

• Keep animals clean and dry by doing the following:

- Scrape manure buildup from floors.
- Maintain animal health to avoid loose stools.
- Provide optimal, comfortable temperature.
- Provide recommended space per animal in the pen.
- Provide proper ventilation air distribution and airflow rate to ensure dry floor and proper dunging patterns.
- Repair leaky nipple waterers to keep floors dry.
- Maintain waterers at the proper height.

• Use flow-through pen partitions to help keep floors dry.

Pig Diet Manipulation and Feed Additives

• Use good quality drinking water low in sulfates and nitrates.

• Use split-sex feeding to enhance nutrient efficiency and reduce nutrient excretions.

• Use proper grinding and/or pelleting to enhance digestibility of feeds and reduce nitrogen excretion by 20 to 24%.

• Use phase-feeding to enhance nutrient efficiency and reduce nutrient excretions. Dutch research has shown that a three-phase feeding program can reduce ammonia emissions 45% and odors 55%.

• Use wet feeding (3:1 water to feed ratio) to reduce odors from 23% to 31% by reducing water and feed spillage.

• Add oils and fats to feed (1% or more) to reduce production of dust, which carries odor.

Feed Handling

• Maintain and adjust feeders to reduce feed loss, which can be a significant cost to the operation. Excess feed spillage adds unnecessary nutrients to manure and can also cause odors from spoilage. Using "good housekeeping" practices to routinely clean up spilled feed from solid floors is imperative.

• Keep dust from feed handling operations to a minimum with low-dust emission feed distribution systems, e.g., totally enclosed delivery to covered feeders.

• Use wet-dry feeding systems to reduce dust in the building.

• Use pelleted feed to reduce dust.

Carcass Disposal

• Remove mortalities from the site to a rendering facility within 24 hours.

• If removal is not feasible:

- Refrigerate.
- Incinerate. Odor abatement technology (afterburners, etc.) is expensive.
- Compost.
- Bury, if allowed by regulations. Carefully site and manage burial pits.
- Grind and treat anaerobically in a special treatment facility.

Manure Storage Tanks and Basins (High-Load Systems)

• Agitate and pump when favorable wind conditions exist (brisk breeze blowing away from neighbors). Always agitate slurry with the pump exhaust spout below the surface.

• Place permeable cover or biocover (straw) on storage and bottom load the manure. Covers limit solar heating and wind-induced volatilization. They provide an aerobic zone within the cover material, with high surface area for filtering and aerobic degradation of odors and other gases emitted from the slurry. Natural crust (occurs with high-fiber diets such as barley-based diets) may reduce odors by 50%. The costs of artificial biocovers range from $0.25 to $0.40 per pig marketed. A chopper pump may be needed during pump out. Most biocovers last about 2-3 months and must be replaced each time manure is removed. Permeable covers and biocovers include the following.

- Chopped barley, wheat, oats, or brome straw (8-12 inches thick) give about 50-80% odor reduction. Cost is estimated at $0.01 to $0.02 per square foot.
- Chopped corn stalks (8 inches thick) cost less than $0.01 per square foot, but are not as effective for odor control as straw.
- An impermeable floating plastic cover is very effective (>99% odor reduction). Cost is about $0.35 to $0.45 per pig marketed.

• Use properly managed composting for effective odor control. Cost is estimated at $0.20 to $0.40 per head marketed.

Anaerobic Lagoons (Low-Load Systems)

• Avoid overloading lagoons with manure. Never exceed the design loading rate, especially in winter and spring.

• Reduce loading rate by separating solids from liquids or hauling away some liquid manure when fields can accept it. Avoid shock loading the lagoon. Add small amounts of waste frequently (less than seven days) rather than large quantities irregularly. Never add dead animals, carcass parts, or human sanitary wastes to lagoon.

• Add dilution water to avoid odors during warm-up periods. The rule in Indiana is one part water to one part manure. Some increased bacterial activity and turnover of lagoons are natural in the spring and fall.

• Agitate and dewater lagoons when winds are blowing away from neighbors.

• For best results, start a lagoon gradually in late spring, and follow standard dilution procedures (fill a treatment lagoon to design volume before adding waste, etc.).

• Start a lagoon with several tanker loads of sludge from municipal sewage treatment plants or other established lagoons (if treated manure is not returned to the barns for dilution and flushing).

• Agitate and remove sludge from a first stage lagoon every three to four years to reduce buildup.

• Add waste to a lagoon at multiple locations to distribute evenly through the lagoon.

• Minimize use of feed additives such as antibiotics and heavy metals, which can reduce bacterial decomposition.

• Consider permeable floating biocovers for relatively small lagoons. They are not practical for very large surface areas.

• Use surface aeration to increase aerobic digestion if proper loading cannot be achieved. Though surface aeration is energy intensive, the amount of aeration required to control odor is much less than required for significant treatment of the manure to reduce the organic matter. Costs range from $0.50 to $2.00 per pig marketed for fixed costs and $0.50 to $1.50 per pig marketed for variable costs. Static tube aeration systems are more efficient and less costly to operate than floating aerators. Pulse aeration and low-rate aeration are options to reduce odor emissions, but additional research is needed. Recent field tests indicated over 80% less odor emission from a surface-aerated lagoon as compared to two unaerated lagoons which were loaded at only half the rate.

Land Application

• Do not spray irrigate concentrated liquid slurry from manure tanks and basins.

• Inject manure into the soil to control odors. The cost is about $0.40 to $0.50 per pig marketed or $0.003 per gallon of slurry based on equipment costs. If equipment is available to inject, the fertilizer value of the extra nutrients saved more than justifies the cost.

• Avoid agitating and surface-spreading manure storage on still days, or when wind is blowing toward neighbors.

• Avoid applying manure on weekends, holidays, or when social events are taking place.

• Surface-apply manure during good drying conditions, e.g., early morning, low humidity, high wind, clear sunny weather, and on tillable soil.

• Surface-apply manure when airflow patterns are turbulent or rising.

• Reduce application rates of surface-applied manure to promote drying and reduce odor release.

• Incorporate surface-applied manure as soon as possible after application, preferably as it is applied.

• If irrigating, use low-trajectory, low-pressure systems. Install drop nozzles on an existing system to minimize odors.

• Size manure storage large enough to limit manure applications to as few (1-3) times per year as possible.

Outdoor Lots

• Minimize the use of outdoor lots, because odor emission is directly related to the lot surface area over which the manure is deposited.

• Slope dirt lots at 4-6% to the S or SE to enhance drying and drainage. Capture contaminated runoff, and apply to crop land. Divert clean roof water and external rainwater around the lot to keep the lot drier.

• Remove solid manure often for field application or to long-term storage to minimize the surface area for odor emissions.

• Divert clean water and other lot runoff away from the solid manure storage to facilitate drying.

Methods Under Research and Development

Buildings

• Biofiltration of exhaust air is an aerobic oxidation process that breaks volatile compounds into carbon dioxide, water, and mineral salts. It works well for low odorant concentrations (<20 ppm). In one study using compost and dark red kidney bean straw for a biofilter bed, farrowing house odors from a pit fan were reduced by 78% and ammonia by 50%. In another study, gestation/farrowing house odors were reduced by 95%, and hydrogen sulfide by 90%. The cost was $0.22 per pig in the U.S. gestation/farrowing facility.

• Spraying oil on surfaces to keep settled dust from going back into the air could result in a 50% reduction in odors. Cost is estimated at $1.15 per pig marketed, with 70% of the cost in labor. More field research is needed to deal with problems of increased cleanup between animal groups and slippery floors.

• Installing zone radiant heat and thus lowering building temperature may lower slurry temperature in below-slat storages.

• Installing vertical stacks or chimneys exhausting above the ridge line could, in some cases, better disperse exhaust odor. However, the method is only likely to be successful when houses are located very near the farm causing the nuisance. Often, tall chimneys are too expensive for the benefit achieved because of the high airflow rates in the summer. They have to be insulated and secured with guy wires.

• Chemical additives can be added to deep pits. Field tests showed approximately a 28% year-round reduction in ammonia emissions by delivering Alliance™ in metered amounts to the pit surface in grow-finish buildings. Some additives may help to maintain the nutrient value of manure, but the responses are variable, and the effect on odor is often questionable due to lack of proper testing. The cost ranges from $0.25 to $1.00 per pig marketed.

• Chemical deodorants or oxidants can be added to the underfloor manure storage. Dosages of example oxidants are 100-125 ppm of hydrogen peroxide and 100-500 ppm of potassium permanganate, but the effectiveness of these chemicals not known. Warning: These chemicals can be hazardous if not handled properly!

• Digestive/biological pit additives have been used with apparent effectiveness in the laboratory, but field tests are needed.

• Cooling the top 4 inches of slurry to 59 F or lower by recirculating ground water in a closed-loop geothermal system has reduced ammonia emissions up to 75% in nursery. The initial investment cost was $29.50 per pig space, and the annual cost was $4.70 per pig space.

• Wet scrubbing of exhaust air with chemicals or with water can significantly reduce odors (27 to 66%), but it is very expensive.

• Low-maintenance aerodynamic dedusters have removed 80% of odorous dust from exhaust air in tests. This experimental method may be too expensive, and it requires field testing.

• Catalytic converters have potential but are currently too expensive. Long-term research is needed.

• Ozonation oxidizes malodorous substances in swine house air. It is important to have sufficient contact time, to obtain even distribution in the air, and to keep the ozone at concentrations below the maximum permissible level.

• Windbreak walls erected 10 to 20 ft. downwind of the exhaust fans will remove some of the dust and deflect odorous air upward for better mixing with the atmosphere.

Pig Diet Manipulation and Feed Additives

• Reducing crude protein and supplementing with synthetic essential amino acids has been researched. The maximum crude protein reduction obtainable by limiting essential amino acids appears to be 3%. Studies show that reduced crude protein diets can reduce nitrogen excretion from 28% to 44% and ammonia from 28% to 45%. However, recent studies also show that even though ammonia and odors were reduced with a 4% crude protein reduction, pig performance was reduced and carcass fat content increased.

• Adding fiber sources such as small amounts of soybean hulls or dried sugar beet pulp to low crude protein pig diets has been studied. Addition of cellulosic-type fiber or non-starch polysaccharides can reduce nitrogen excretion and ammonia (up to 68%) and odorous organic compounds according to recent studies. Oligosaccharides can also reduce ammonia excretion by 24%.

• Adding organic acids to feed has given variable pig performance improvement, but little testing has been done for effect on odors. Use of calcium benzoate, calcium chloride, and calcium sulfate to replace calcium carbonate in diets has reduced urea excretion in urine and ammonia emissions from manure. However, the cost of these calcium salts is high compared to calcium carbonate. This substitution of the calcium form changes the dietary electrolytic balance in feed. Benzoic acid can reduce ammonia emissions by 40% at a cost of $1.13 per pig marketed.

• Minimizing sulfur-containing amino acids and mineral sulfates will reduce sulfur-based gases. Research has indicated that high levels of cystine and methionine along with sulfate minerals can affect odorous sulfide compounds. In one study, reducing the methionine and mineral sulfates in the diet reduced odorous sulfur-containing compounds by 63% and 49%, respectively.

• Sarsaponin, a natural extract of the yucca plant, can reduce ammonia while increasing pig performance. The mechanism of sarsaponin is not well understood. Other feed additives, such as whey and yeast may alter the digestive system in the pig and do affect odor production.

• Odor absorbers such as calcium bentonite, zeolite, sagebrush, and charcoal can absorb odor-causing compounds. However, pig performance may decrease if fed at odor-reducing levels.

Manure Storage Tanks and Basins (High-Load Systems)

• Following are examples of permeable covers and biocovers that still need research and/or further development.

- A manufactured material in the form of self-dispersing granules or powder (German product, Pegulit) results in over 95% reductions in odor, ammonia, and hydrogen sulfide emissions, according to laboratory tests. The product floats back to the surface after agitation. It is not yet available in the U.S.
- Peat moss with wide variety of particle sizes and dried at 212 F for five hours is very effective (>99% odor reduction) at 8 inches thick. Peat moss costs $0.27 per square foot.
- Leka rock is effective but very costly ($5.10 per cubic foot or $0.90 per square foot).
- Some positive testimonials have been reported about using coconut fiber with peat moss added (a German system), tree bark, rice hulls with waste oil, and grass clippings with waste oil. However, scientific tests have not been conducted.

• Cooling the top 4 inches of slurry to 59° F or less with a ground water recycle system has reduced ammonia. Covering the slurry keeps it cooler. An 18° F decrease in temperature cuts the biological reaction rate in half. The cooling recycle system keeps the top layer at about 50-55° F. See "Buildings" in "Methods Under Research and Development."

• Chemical deodorants or oxidants can be added to the slurry. See "Buildings" in "Methods Under Research and Development."

• Slurry can be acidified (pH 3 to 5) with lactic acid or other organic acids to reduce ammonia emissions. Dutch studies have shown that lactic acid fermentation conditions can be created by adding lactic acid bacteria and maintaining the bacterial culture with potato starch or milled wheat that can reduce ammonia emissions by 80%. The effects on other odors are uncertain. The cost for the system was $4.60 per pig marketed. Use safety precautions with acids.

• Ozonating slurry is effective but currently may be too costly. Ozone concentrations in the air should be monitored, because high levels can be toxic.

• Methane generation through anaerobic digestion systems can be effective. An additional carbon source may be needed because hog manure is very high in nitrogen. While this is an effective odor control system, it is very costly (fixed cost estimated at $5.00 to $12.00 per pig marketed). Nutrients in the digested sludge must be land-applied or further processed. Increased management is required. Energy captured as methane may cover variable costs. Though anaerobic digestion units have worked well with large dairy and poultry operations, economical systems for swine have not been fully developed.

• Solids-liquid separation for liquid manure is somewhat effective in reducing odors. Proper management and procedures in the process are critical. The estimated cost is highly dependent on number of pigs marketed and is much more economical for larger units.

Anaerobic Lagoons (Low-Load Systems)

• Planting trees around the lagoon perimeter and the buildings can deflect the odors upward into the air for greater dilution and dispersion. Costs have been estimated as low as $0.15 per pig marketed. However, the benefits are uncertain.

• Anaerobic photosynthetic bacteria oxidizes odorous compounds using solar energy. Research is being conducted to learn how to seed and produce these purple photosynthetic bacteria.

• Digestive/biological additives have been used with apparent effectiveness in the laboratory, but field tests are needed.

Public Perception

To complement the responsible, effective measures you take to reduce odor from your swine facilities, you can also act to reduce complaints and build understanding. Public perception of your pork production facility is very important. Apply a "good neighbor" policy, listen to and acknowledge the concerns of your neighbors, be active in the local community, and maintain an attractive farm. See Purdue Extension publication ID-221, "The Rural/Urban Conflict," for more information on how farmers and non-farm rural residents can be good neighbors.

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