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Water Quality & Waste Management

Effects of Manure Management Practices on Air Quality and Animal Performance in Swine Production Buildings

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Swine production operations, particularly high-density large-volume units, must be planned as a total system beginning with site selection. With increasing emphasis on a cleaner environment, more attention must be given to methods of manure management. Planning a group of buildings and their surroundings to present a wholesome image is as important as planning for productive efficiency. Farm operators who take pride in maintaining the farmstead are generally better managers than those who practice poor housekeeping. Employees take more pride in their jobs and work output improves.

Production advantages are also likely to be realized by proper in-house manure management. Anaerobic decomposition of manure produces more than 40 gases which may be detrimental to animal health and productivity, unhealthy to workers or offensive to neighbors. Ammonia and other gas concentrations in swine housing has been closely associated with ventilation rates and manure management systems. Continuous breathing of ammonia, even in low concentrations, increases the susceptibility of animal's to respiratory diseases such as rhinitis and chronic pneumonia. Ammonia also causes a loss of appetite resulting in slower gains. Hydrogen sulfide, when rapidly released during agitation of stored manure, is toxic and can kill quickly. The presence of dried manure on floor surfaces contributes to dusty conditions inside a production facility which can also damage an animal's respiratory structure.

Therefore, proper consideration should be given to the manure management system in the planning stages both from a production and environmental standpoint to meet the objectives of enhancement of the operational efficiency of the production unit and prevention of nuisance conditions.

RELATED WORK

Donham et al. (1985) characterized different chemical and physical parameters by taking multiple measurements of liquid manure from storage pits in 23 swine confinement operations over a 6-month period. Low temperature, high ammonia content, excess hydrogen ion content and excess volatile solids were often inhibitory or toxic for anaerobic digestion in the pits. Relative to optimal anaerobic digestion, bacterial metabolic reaction rates were slow, production rates of methane and other gases were relatively low, odorous intermediate products (organic acids and sulfur-containing compounds) were relatively high and waste stabilization was relatively low. These characteristics were accentuated in grower and finishing buildings. They also observed that only a portion of the ammonia present in the air of confinement buildings comes from the manure pits with the rest from the urine and feces on top of slats and solid floor surfaces.

Virginia swine producers noted more infectious rhinitis and pneumonia in their pigs during changeable or cold weather (VPI&SU, 1980). It was found that when exhaust fans are significantly slowed or stopped, that there is a rapid buildup of ammonia (up to 75 ppm) and carbon dioxide (up to 9,000 ppm). In addition, inside relative humidity climbed to as much as 24% higher than the outside relative humidity, often reaching 85% or greater. With little fresh, clean air coming in to mix with the inside air, germs accumulated in the air, due to the pigs breathing, and from the urine and manure being moved around. With little or no air flow, moisture appreciated by the fact that it readily condensed on cold windows, walls and ceilings. The source of this moisture was primarily from the pig's breathing, from urine, manure, wet feed, and spraying done during clean-up. If the relative humidity stays above 85% consistently, germs in the air that would normally die by drying out, do not. They concluded that good ventilation is not just good temperature control; it must also include moisture, waste gas, and germ control, in order to have healthier pigs.

Drummond et al. (1980) assigned 4-week old pigs from each of two litters to one of four controlled environment growth chambers. These chambers were randomly assigned to one of four ammonia concentrations: 0 (control), 50, 100, or 150 ppm of aerial ammonia. Exposure was constant for four weeks. Pigs in the 50 ppm ammonia environment showed a 12% reduction in daily gain compared to the control group. The daily gain of pigs in both the 100 ppm and 150 ppm ammonia chambers dropped 30% below the control. In addition to suffering growth depressions, the pigs exposed to 100 or 150 ppm of aerial ammonia were lethargic in comparison to the controls or those at 50 ppm. Coughing was only apparent among pigs at the 100 and 150 ppm level. Excessive tearing from the eyes was noted in all pigs exposed to aerial ammonia causing black patches to develop from the corner of the eye. The size of the patches was directly proportional to the ammonia concentration.

In another test, pigs were put in a chamber with aerosolized bacteria. The pigs breathed in bacteria-filled air for 10-15 minutes. Then one group was put in a chamber with a clean, cool atmosphere and another group put in a chamber with an ammonia atmosphere. Fifty percent more bacteria were found alive in the lungs of pigs in the ammonia environment than in the pigs in a clean environment.

Pigs in a control group with no ammonia or roundworms were gaining 1.17 lb/day. Another group of pigs with just ammonia in the atmosphere gained 0.79 lb/day while the group of pigs with just roundworms gained 0.84 lb/day. Pigs with both roundworms and ammonia gained less than 0.5 lb/day, a 60% reduction from the control group.

Ammonia combined with bordetella bronchiseptica did not show any increased deleterious effects on rate of gain. But the ammonia did increase nasal turbinate shrinkage in the bordetella pigs. There was some additional turbinate shrinking in pigs exposed to both 50 ppm ammonia and bordetella than pigs with just bordetella. And pigs exposed to 100 ppm showed even more shrinkage.

Elanco Products Company sponsored a series of total respiratory analysis and control clinics during the summer of 1984 where more than 10,000 hogs were checked at slaughter from 337 herds across 13 states. Veterinarians working for herd owners checked snouts, lungs and livers of hogs for signs of rhinitis and pneumonia. Seven out of 10 hogs checked had either rhinitis or pneumonia. Conclusions were that rhinitis and pneumonia cost the average producer a loss of 6.3% in average daily gain, or about $2.46 per market hog. The most severe case of the two diseases combined can reduce daily gain by 40%, delay reaching market weight by more than 3 months, and cost $19.03 extra per head to produce.

Sutton et al. (1986) compared two groups of gilts on concrete slotted floors over 4-foot deep pits. One group was housed over a pit where manure was allowed to accumulate throughout the experiment (control). The pit under the other group was drained and refilled with clean water biweekly (clean). The two rooms had similar feeding, water, floor space, lighting and room temperature. Ventilation fans with timer controls ran twice as long in the clean environment as in the control environment. Weight gains and feed efficiencies were similar for both groups. Gilts were delayed in the age on onset of puberty when housed in the control environment as compared to the clean environment. There was a noticeable difference in air quality between the two rooms. Ammonia levels were 20 and 5 ppm in the control and clean rooms, respectively. Watering of eyes and irritation of the nose were distinct results of being present in the control room with no obvious irritations while being present in the clean room.

Meyer and Converse (1981) concluded from a study of the daily production of ammonia and hydrogen sulfide from simulations of nursery buildings with both below-floor and above-floor level Y-gutters or shallow pits, that manure needs to be removed from the building before 5-7 days to achieve the goal of reduced odor and gas levels. In their study, the hydrogen sulfide and ammonia gas productions at 23o C started increasing at the 3rd and 5th day and reached their peak at the 21st and 16th day, respectively. Banwart and Bremner (1975) reported that hydrogen sulfide evolution did not significantly occur until after 6-8 days of incubation at 23o C.

Barker and Driggers (1985) reported on a 600-sow farrow-to-finish confinement unit where the finishing facilities were converted from long-term underfloor pit storage of manure to weekly pit recharge. After 2 months, most of the old accumulated manure solids had been removed from the pits. In the first 6 months after conversion, hogs from these units were going to market 6 pounds heavier, 10 days earlier, and with a 0.1 pound better feed conversion. Mortality, which had ranged up to 4 percent went down to 0.75 percent. The injectable and water-administered medication for the animals was cut in half. These benefits when calculated on a $54 hog market meant an additional $3 net per animal sold from this operation designed to market 10,000 slaughter animals per year.

Hudson (1983) reported the results of changing the frequency of pit recharge in a swine confinement building in South Carolina. The farm owner noticed a drop-off in herd productivity during the winter of 1983. A significant increase in rhinitis in animals on the finishing floor was also noted and attributed to stress. They also had a reduction in conception rate and in numbers of pigs per litter. After checking for stress-related factors they decided to begin draining and recharging the pits with lagoon liquid every week instead of once in 4 to 5 weeks as they had been doing. The production level began to improve again and medication was reduced considerably. Pit gasses not obvious to the workers were affecting herd reproduction, health and performance.

Muehling (1989) reported on several case studies in central Illinois concerning improvement of the air quality in swine buildings. Farm A, a 1200-sow farrow-to-finish confinement farm, spent less than $1,000 to convert from an underfloor scraper system to pit recharge. Building ammonia levels decreased from 50-70 ppm with scrapers to 5-10 ppm with the pit recharge system.

Farm B, another farrow-to-finish farm producing 8,000 hogs per year, spent $9,700 to convert 6-foot deep manure storage pits to a combination earthen settling basin - anaerobic lagoon - pit recharge system. The farm owner indicated that conditions inside the buildings were greatly improved with the new pit recharge system. The pits had up to four feet of solids buildup, most of which has been eliminated. He also related that the pits seemed to always be full at the most inopportune time to haul the manure to his fields. With the present system, he can plan when he wants to haul sludge from the settling pond or pump liquid from the lagoon.

Farm C, a 350-sow farrow-to-finish operation, spent $23,000 to convert the manure system from pit storage to a system where the pit contents drain into a sump, a pump lifts manure to a covered concrete solids separation basin, liquids flow to an anaerobic lagoon, and lagoon liquid is recycled for pit recharge. The worst pit contained 16 inches of sludge. After several months of pit recharge, less than 6 inches of manure remains and the level is still decreasing. Before changing to the pit recharge system, ammonia concentrations as high as 65 ppm were measured in the finishing houses. The ammonia readings have fallen to less than 15 ppm. The farm owner indicated that pit recharge has given better hog health with fewer pneumonia problems. They have nearly eliminated the use of feed and water medications and have a more pleasant work environment for the herdsmen.

Bailey (1992) conducted a North Carolina study in Sampson County during the winter of 1991 of the ammonia levels of swine finishing buildings having different ventilation and manure management methods. Five pit recharge buildings were monitored with the following characteristics: a pit depth of 24-32 inches; a pit slope of 1 inch per 20-40 feet; a pit emptying and recharge frequency of 1-3 weeks; and winter ventilation through plenum openings under slats. Eight flush under total slatted floor buildings studied had these characteristics: pit depth of 16-24 inches; pit slope of 1-2 percent; flush frequency of 4-6 hours; and winter ventilation through plenum openings under slats. Four buildings had partial slatted floors with flush under slats: pit depth of 8 inches; pit slope of 1.5-2 percent; flush frequency of 4-6 hours; and winter ventilation through forced air tube. Nine tunnel ventilated houses had these characteristics: pit depth of 8 inches; pit slope of 1 percent; flush frequency of 4-6 hours; and winter ventilation through side wall air inlets and exhaust fans at one end of the buildings. Four pit storage buildings were also studied: pit depth of 40 inches plus; pit slope of 1 inch per 20-40 feet; pit emptying frequency of 6 weeks to 5 months; and winter ventilation through plenum openings under slats.

Ammonia levels in the buildings during these studies averaged 7.4 ppm in the pit recharge buildings, 13 ppm in the flush under slat buildings, 18 ppm in the partial slatted floor houses, 24 ppm in the tunnel ventilated houses, and for the pit storage buildings 16 ppm when the pits were emptied on a 6-week frequency and 30 ppm when they were emptied every 5 months. Medication costs for animals in the pit recharged buildings ranged from $2.37 to $2.62 per head, while these costs in the pit storage buildings were $4.33 to $6.49 per head.

SUMMARY

After weighing the important points of alternative manure management systems, a producer must decide which system appears best, then commit to providing the attention and management necessary to make the system function. No waste system will take care of itself. The appearance of buildings and grounds on swine farms constantly generates images of the product, good or bad. **A good swine image helps sell the product.** Portraying an attitude of success is contagious -- to employees, to neighbors, to consumers and to the general public (Morris et al., 1973).

REFERENCES

Bailey, D.E. 1992. Gases and air quality problems that can affect worker and animal health in swine facilities Proc Wilson Regional Pork Conference, Wilson,NC, Nov 24. 12 pp.

Banwart, W.L. and J.M. Bremner. 1975. Identification of sulfur gases evolved from animal manures. J Env Qual. 4(3):363-366.

Barker, J.C. and L.B. Driggers. 1985. Pit recharge system for managing swine underfloor manure pits. ASAE Publ 13-85, Agricultural Waste Management and Utilization, ASAE, St. Joseph,MI. pp. 575-581.

Donham, K.J., J. Yeggy and R.R. Dague. 1985. Chemical and physical parameters of liquid manure from swine confinement facilities: health implications for workers, swine and the environment. Agri Wastes. 14(1985):97-113.

Drummond, J.G., S.E. Curtis, J. Simon and H.W. Morton. 1980. Effects of aerial ammonia on the growth and health of young pigs. J An Sci. 50:1085.

Elanco Products Co. 1984. Respiratory diseases cost $2.46 per hog. Pork 85. Aug 1985 Issue.

Hudson, J. 1983. Guerney Rowell survives ups and downs. Southeast Farm Press. Dec 14. pp 23-24.

Lehman, A. 1989. Converting my swine waste management system to pit recharge. Proc 1989. Livestock Waste Management Conference, Univ of Illinois, Urbana-Champaign,IL, Mar 21, pp. 59-62.

Meyer, DJ and JC Converse. 1981. Gas production vs storage time on swine nursery manure. Paper No 81- 4512, ASAE, St. Joseph,MI. 8 pp.

Morris, T.B., W.C. Mills, Jr., and D.G. Harwood. 1973. Profit From Improving Your Image. PS&T Guide No 17, N.C. Agricultural Extension Service, Raleigh, NC. 2 pp.

Muehling, A.J. 1989. Pit recharge waste management system - an update. Proc 1989 Livestock Waste Management Conference, Univ of Illinois, Urbana- Champaign,IL, Mar 21. pp. 52-58.

Sutton, A.L., J.R. Malayer, M.A. Diekman, D.T. Kelly, D.D. Jones and G.G. Long. 1986. Effects of Manure Gases on Swine Health & Production. Paper No 86- 4038, ASAE, St. Joseph,MI. 23 pp.

Virginia Polytechnic Institute & State Univ. 1980. The lack of proper ventilation in cold weather can lead to to respiratory disease in pigs. NCSU Vet Info, Dec.

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