Dust and Ammonia Control in Poultry Production Facilities Using an Electrostatic Space Charge System

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Species: Poultry
Use Area: Animal Housing
Technology Category: Electrostatic Space Change
Air Mitigated Pollutants: Particulate Matter and Ammonia

Description:

Air quality within poultry production housing has been a major concern for years, particularly with regard to poultry health. Environmental concerns and nuisance issues related to agricultural air emissions are now affecting all aspects of animal agriculture. Dust or Particulate Matter (PM) is a component of air emissions that may play a role in the transport of gaseous and odorous compounds. Dust concentrations in poultry houses have been reported to vary from 0.02 to 81.33 mg/m^3 for inhalable dust and from 0.01 to 6.5 mg/m^3 for respirable dust (Ellen et al., 2002). Sources of dust in poultry houses include feed, down feathers, excrement, microorganisms, and crystalline urine (Aarnink et al., 1999). Factors that affect dust levels in poultry houses include animal activity, animal density, and moisture conditions. Dust can contain large numbers of microorganisms that could have potential impact on human and bird health.

Reducing airborne dust in enclosed animal housing has been shown to result in corresponding reductions in airborne bacteria, ammonia, and odor. Studies have shown that reducing airborne dust levels by 50 percent can reduce airborne bacteria by 100 fold or more (Madelin and Wathes, 1988; Carpenter et al., 1986). The search for strategies to reduce particulate matter and ammonia emissions from animal housing has led to considerable interest in the poultry industry for practical systems to reduce these air emissions.

Several approaches can be used to reduce dust concentration within animal housing. These include the addition of fat to the feed, fogging with water and oil-based sprays, ionization, electrostatic filtration, vacuum cleaning, wet scrubbers, and purge ventilation. Reductions reported with these approaches ranged from 15 percent for weekly washing of pigs and floors, to 76 percent with a rapeseed oil spray (CIGR, 1994). Reports of ionizer efficiency have ranged from 31 percent (Czarick et al., 1985) to 92 percent (Mitchell et al., 2002).

Dust in broiler houses originates from the litter base. Bedding type, humidity, and temperature affect the dust concentration. High moisture levels in the air facilitate the absorption of ammonia into dust particles and the inhalation of the dust particles containing ammonia can cause damage to the respiratory tract (Kristensen and Wathes, 2000). Ammonia in broiler houses originates from the litter base. Bedding type, litter management, humidity, pH, and temperature affect ammonia concentration and release. For broiler house ammonia, reduction of in-house aerial concentrations has been largely accomplished through ventilation. Another trend in the industry is less-frequent, complete-house, clean-out resulting in birds being grown on built-up litter. The manure cake is removed between flocks and the remaining litter is top-dressed with new bedding material. The combination of these trends can be detrimental to air quality in broiler houses if dust and ammonia levels are not managed, particularly during the brooding phase.

An Electrostatic Space Charge System (ESCS) described by Mitchell and Stone, 2000, has been shown to significantly improve air quality by reducing airborne pathogens and disease transmission in poultry. The principle behind the ESCS is to transfer a strong negative electrostatic charge to airborne dust particles within an enclosed space. The negatively charged particles will then precipitate out of the air as they are attracted to grounded surfaces. Nitrogen compounds attached to the dust will also precipitate out with the dust.

Based on the work be Mitchell and others, an ESCS was designed to determine whether a practical system can be developed for operation in a commercial broiler production house. The system was evaluated for effectiveness of this technology for improving air quality in the house through reductions in concentrations of dust and ammonia.

Mitigation Mechanism:

A custom-made ESCS system was designed and installed in a 500 ft x 40 ft tunnel ventilated commercial broiler house. The system consisted of four rows of in-line, negative-air ionization units with two 200 ft rows on each side of the house in the brood end and two 200 ft rows in the grow-out end, as shown in FIGURE 1. Separate high voltage

(-30 kVdc, 2 mA) power supplies were used to supply -25 kVdc to the ion generators in each half of the house. The high voltage power supply for the ESCS was current limited to a safe level of 2.0 mA. The in-line generators consisted of a conductive tube with electrodes at one-in. intervals and attached to a grounded one-in. diameter black iron pipe. The iron pipe was located 3 in. above the discharge points to provide a close proximity ground plane and to increase the negative ion output. The ESCS was positioned to a height of seven ft above the litter which was sufficiently high to walk under but low enough to concentrate the charge near the birds where dust is generated. A broiler house adjacent, and essentially identical, to the treatment house was instrumented for airborne dust and ammonia monitoring but operated without ionization. Each house was initially bedded with pine shavings and the caked litter material around the feeders and drinkers was removed between each flock followed by a thin top-dressing of new shavings.

Dust concentrations were measured with a TSI DustTrak (TSI), a laser-based instrument with a particulate range of 0.001 to 100 mg/m^3. Aerial ammonia was measured with a Draeger Polytron I (Draeger) electrochemical sensor with a sensitivity range from 0 to 100 ppm. Data were collected for three sampling periods during each of seven flocks during the first, third, and fifth weeks of production. Air samples were collected continuously for approximately five d during each period. Sampling frequency was once every 15 minutes for dust and once every minute for ammonia. Mean concentrations were calculated for each sampling period. Due to the large amount of collected data during each sampling period, hourly means were generated to calculate the sampling period mean.

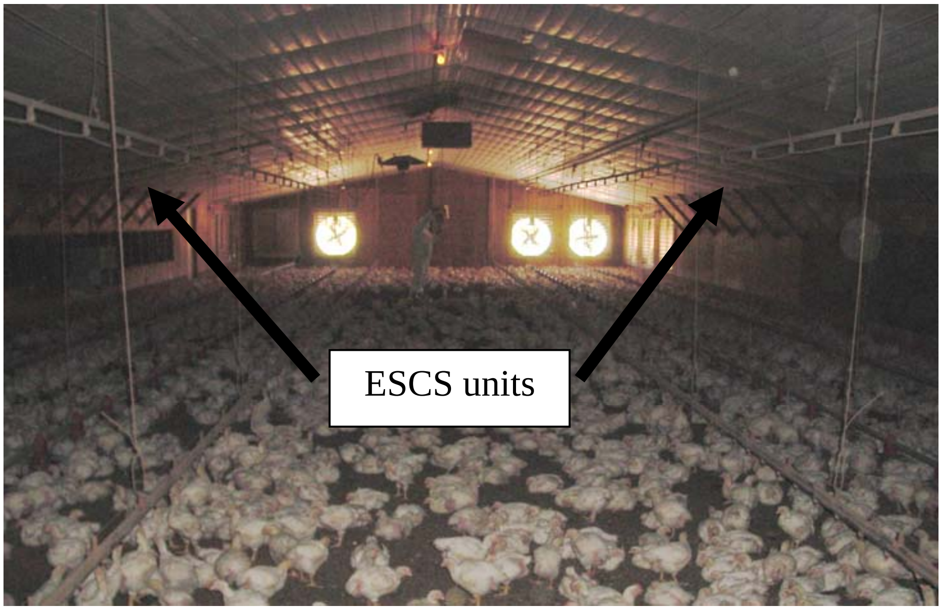

FIGURE 1. Electrostatic space charge unit assembly within a broiler house.

Applicability:

Results from this study suggest that an ESCS can be effective in reducing poultry house dust and ammonia concentrations in floor-raised meat-bird housing where bedding material is utilized. The system will likely require considerable modification for use in high rise layer facilities or used as an emissions control device exterior to the animal housing. However, the principles of the technology remain as follows: to produce an electrostatic space charge that will reduce aerial dust and ammonia concentrations.

Limitations:

The incidences of static discharge to workers were minimal. The intensity of a discharge from direct contact with an ESCS ionizer was similar to touching a spark plug wire on a gasoline engine.

Cost:

The cost of materials and installation of the experimental ESCS unit was approximately $4,000. Power consumption of the entire system was less than 100 watts during operation. It is reasonable to assume that a commercially available product would have a reduced capital outlay and quicker return on investment than the experimental prototype used within this study.

Implementation:

Figure 2 is an example sampling period showing the reduction of dust concentrations as influenced by the ECSC within the broiler house. After seven flocks were studied with the ESCS in place, the data indicate the ESCS significantly reduced airborne dust by an average of 43 percent and reduced ammonia by an average of 13 percent (Table 1).

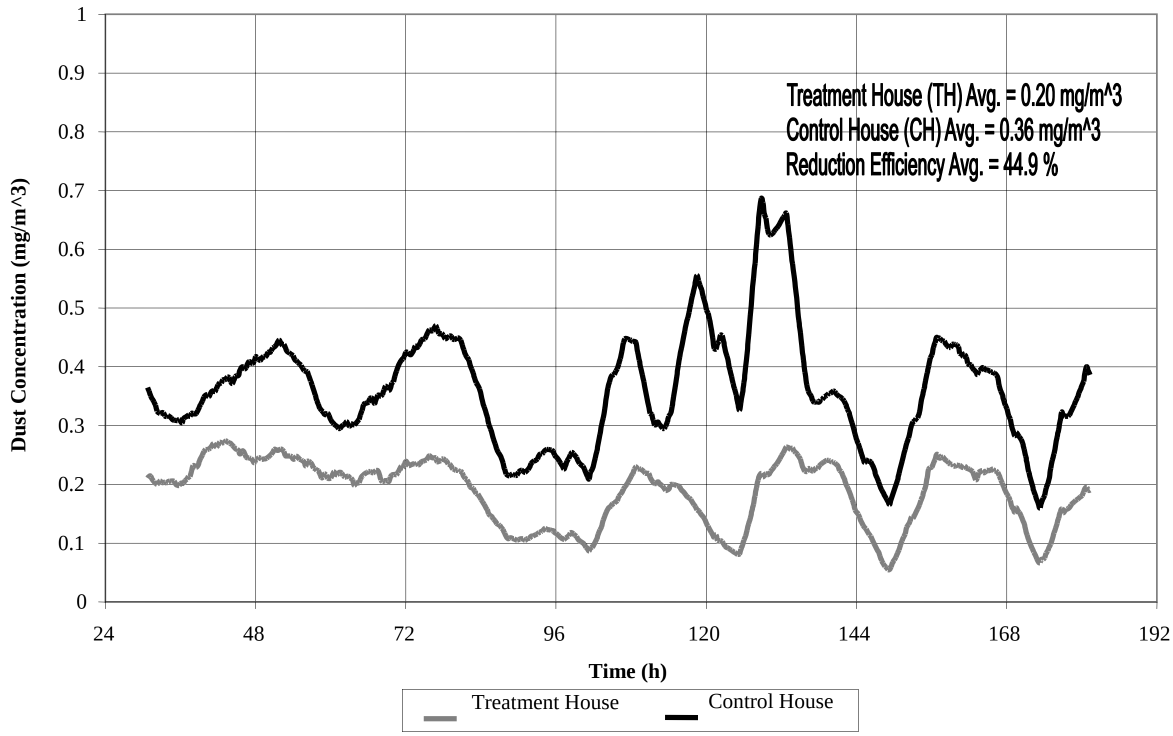

FIGURE 2. Example sampling period showing the reduction in dust concentrations within the treated and non-treated broiler houses.

TABLE 1. Efficiency of electrostatic space charge system (ESCS) for reduction of broiler house dust and ammonia concentrations.

Flock	Period	Dust Concentration Mean (mg/m^3)			NH_3 Concentration Mean (ppm)		
		Control	Treatment	Reduction %	Control	Treatment	Reduction %
1	Jan-Feb	1.13	0.60	46.9	44	38	13.6
2	Mar-Apr	0.48	0.27	43.7	54	46	14.8
3	May-Jun	0.14	0.09	35.7	24	19	20.8
4	Jun-Jul	0.49	0.36	26.5	20	17	15.0
5	Aug-Sept	0.47	0.23	51.1	12	11	8.3
6	Oct-Nov	0.63	0.38	39.7	31	27	12.9
7	Nov-Dec	1.10	0.44	60.0	51	47	7.8
Mean ± SEM		0.63 ± 0.030	0.34 ± 0.014	43.4 ± 0.913	34 ± 1.369	29 ± 1.187	13.3 ± 4.086

Technology Summary:

Electrostatic Space Charge technology can be used to mitigate dust and ammonia emissions within poultry production facilities and may have application as an emissions control strategy. Research suggests that reduction in dust can exceed 40 percent while ammonia concentrations can be reduced 10-15 percent. The effectiveness of the system is increased with higher dust concentrations. Reducing ammonia concentrations inside poultry houses may require separate control strategies than those designed for dust reduction in order to ameliorate poor air quality and emissions attributed to ammonia. Cost of the system for an individual poultry house will depend on mass production of the needed materials, though the overall cost will likely be lower than the $4,000 needed for the experimental unit described in this study. Electrostatic fields have not been shown to produce adverse health effects in animals or humans. No differences in bird activity were observed in the form of decreased water consumption or increased mortality and no adverse effects of the continuous charge were observed in the form of stray voltage or static discharge at the feeder and water lines.

Additional Resources:

RITZ, C.W., B.W. MITCHELL, B.D. FAIRCHILD, M. CZARICK, AND J.W. WORLEY, 2006. IMPROVING IN-HOUSE AIR QUALITY IN BROILER PRODUCTION FACILITIES USING AN ELECTROSTATIC SPACE CHARGE SYSTEM. *JOURNAL OF APPLIED POULTRY RESEARCH* 15:333-340.

Acknowledgments:

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References:

Aarnink, A.J.A., P.F.M.M. Roelofs, H. Ellen, and H. Gunnink, 1999. Dust sources in animal houses. Pages 34-40 in Proc. International Symposium on "Dust Control in Animal Production Facilities", Aarhus, Denmark.

Carpenter G.A., W.K. Smith, A.P.C. MacLaren and D. Spackman, 1986. Effect of internal air filtration on the performance of broilers and the aerial concentrations of dust and bacteria. Br. Poult. Sci. 27:471-80

CIGR Working Group 13, 1994. Aerial environment in animal housing - Concentrations in and emissions from farm buildings. "Climatization and Environmental Control in Animal Housing". Pages 83-112 in CIGR and CEMAGREF, Report No. WG No 94.1.

Czarick, M.I., G.L. Van Wicklen and R.A. Clemmer, 1985. Negative air ionization for swine during weaning. Transactions of the American Society of Agricultural Engineers, paper 85-4510.

Ellen, H.H., R.W. Bottcher, E. von Wachenfelt, and H. Takai, 2000. Dust levels and control methods in poultry houses. J. Agric. Safety & Health 6:275-282.

Kristensen, H.H. and C.M. Wathes, 2000. Ammonia and poultry welfare: a review. Worlds Poult. Sci. J. 56:235-245.

Madelin T.M. and C.M. Wathes, 1988. Air hygiene in a broiler house: Comparison of deep litter with raised netting floors. Br. Poult. Sci. 30:23-37.

Mitchell, B. W. and H. S. Stone, 2000. Electrostatic reduction system for reducing airborne dust and microorganisms. U. S. Patent No. 6,126,722.

Mitchell, B.W., R.J. Buhr, M.E. Berrang, J.S. Bailey and N.A. Cox, 2002. Reducing airborne pathogens, dust and *Salmonella* transmission in experimental hatching cabinets using an electrostatic space charge system. Poult. Sci. 81:49-55.

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