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Evaluation of Air Quality in a Confined Poultry House

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ABSTRACT

Concentrations of Ammonia and Nitrous Oxide gasses in a closed poultry structure were determined and correlated with bird mortality rate in this study. The poultry house was demarcated into 3 and the 2 gaseous pollutants in each of the demarcation were monitored for three days and analyzed in a laboratory to determine the concentration of each of the pollutants in the house. The concentrations of Ammonia, (NH_3), range between 0.60 and 9.99mg/m^3 while the concentrations of Nitrous Oxide, (NO_2), range between 9.82 and 25.00mg/m^3. Average concentration distribution of NO_2 is approximately three times the value of NH_3 in all the 3 divisions and at the time of sampling. The source of the 2 gaseous pollutants is traceable to decomposition of poultry waste present in the pens. The mortality rate of birds in the sampling poultry ranges between 3 and 11, and this follow closely the distribution pattern of NH_3 in the poultry house. It indicates well that the presence NH_3, as pollutant in poultry system, is responsible for poor output.

Keywords: *Poultry, Gaseous pollutants, Ammonia, Nitrous Oxide, Pollution, Mortality, Poultry House*

1. INTRODUCTION

Poultry is an important sector of agriculture, which within shorter generation interval gives returns to the breeder. The birds have high adaptability to climate and altitude, housing, and feeding and confinement and are sources of high protein food and other products like the feathers, all of which are of economic importance. Poultry eggs and meat contribution of the livestock share recorded improvement in Nigeria with its share of the Gross Domestic product (GDP) increased from 26% in 1995 to 27% in 1999 (CBN, 1999). This significant improvement is further sustained by availability and use of improved vaccines, curtailed mortality rates in birds, reduction in the tariff on imported day old chicks and parent stock (CBN, 1999). Furthermore, the relative ease of compounding efficient feed from available local feedstuffs, use of modern housing facilities that reduce mortality rate and enhance optimal performance of the birds are other factors that enhance the record (Ojo and Afolabi, 2000). Consequently, large-scale poultry production based on intensive poultry keeping systems otherwise known as Confined Animal Feeding Operations (CAFOs) with its characteristic closed poultry structure, which provides means for reducing unit costs of production, and suitable environmental conditions that enhance optimal poultry production are fast becoming popular among commercial poultry farmers in the country. Intensive poultry production is being linked with environmental pollutions (Curtis and Drummond, 1982) and gaseous emissions from poultry and livestock facilities is the most environmental issue confronting the industry, both in developed and developing countries (Zahn et al., 1997; Gralapp et al., 2001; Feddes and Liesko, 1993). Consequently, this greatly influences the animal health and weight gain as well pose health risk for poultry stockmen and those living in proximity of the poultry facilities (Donham and Cumro, 1999; Donham *et al.*, 2002; Whyte, 2002). Furthermore, gaseous emissions from poultry and livestock facilities affects sanitary conditions, air quality, heat and pollutant distribution conditions inside birds housing (Baracho *et al.*, 2001).

Chief among the air pollutants found around this environment include odour, dust particulates, ammonia, hydrogen sulphide and nitrogen oxide and other compounds identified in air samples collected from animal production facilities (Miner, 1995). Most studies of noxious gases in livestock pens focused on ammonia (Vučemilo *et al.*, 2007; Moore *et al.*, 1996; Brewer, 1998; Wheeler *et al.*, 2003; Armstrong *et al.*, 2003). High ammonia concentrations in commercial broiler production houses can result in poor bird performance, lower feed conversion ratios, and higher mortalities (Armstrong, *et al.*, 2003). Ammonia role in acid rain formation is equally unfavourable to poultry production (Okoli *et al.*, 2004). However, intensive livestock production contributes to global emission of other important aerial pollutants such as volatile organic compounds(VOC) and reactive organic compounds (ROC) that impact adversely upon the countryside and on the ozone layer (Nahm, 2000). Nitrogen oxide irritates the lungs and lower resistance to respiratory infections such as the flu among farm workers and livestock.

The concentrations of these pollutants in livestock houses and emissions from them have been studied extensively in the developed economies and several comprehensive reviews published highlighted some detrimental effects of these aerial pollutants on human welfare and livestock (Harry, 1978; O'Neil and Philips, 1992, Wathes *et al*., 1997). Such information is however scanty for most tropical farming environments (Okoli *et al.*, 2004), especially in Nigeria. Research on the concentrations and emission rates of pollutant gasses in closed poultry structures often used for intensive poultry production is therefore needed in order to establish baselines for exposure limits in the context of animal and human welfare in tropical environments. The highest air pollutant concentration is found in houses for intensive broiler breeding (Vučemilo *et al.*, 2007), hence, the aim of this study was to determine the concentrations of ammonia and nitrogen oxide in an intensive broiler breeding structure in Ibadan, Oyo state.

2. MATERIALS AND METHODOLOGY

The equipment and materials used for the sampling includes: Aspirators, Boiling tube, L-shaped glass tube, Silicon grease or Vaseline and the reagents include: 1-methyely-diamine dihydrochloride, Hydrogen peroxide, Glacial acetic acid, Hydrochloric acid, Sodium Nitrite Solution.

2.1 Sampling Site

The study was carried out at Zartech International Farm, Ibadan, Oyo state, Nigeria. A mechanically ventilated broiler house of 100 x 14 x 3.6 m was used for the study. The pen was divided into three sections, A, B, C, each with dimension (33 x 14 x 3.6) m, in accordance with the procedure describe by Wathes *et al* (1997). The birds in the pen were 27,446 birds of average weight of 1.0kg and three weeks old.

2.2 Air Sampling

Air sampling method employed in this study follows the procedure suggested by Rao (2007). Two aspirators, each installed with a boiling tube, L-shaped glass tube, Teflon/ connecting tube and a retort-stand were set up in each of the house divisions. Each of the aspirators was filled with water to the upper level and then corked. Sodium nitrite was measured into the boiling tubes to trap samples of ammonium and nitrogen (IV) oxide present in the air. The taps at the bottom of the aspirators were then opened for water to start running out at a constant flow rate, thereby creating a partial vacuum in the aspirator. Consequently, streams of air rushed into the boiling tubes due to pressure difference and the pollutants trapped by the absorbing agent. Samples were collected twice a day; morning (9am) and afternoon (3pm), for three consecutive days (Okoli *et al.*, 2004).

Kjeldahl tube was used for performing the digestion. 5ml of each sample 1 and 2 was pipetted into the digestion tube. Using a measuring cylinder, 20ml of digestion acid was poured into the samples. The tubes with the samples were placed in the pre-heated digestion unit and heated to an appropriate temperature. The tubes were covered to prevent escape of gas and lose of heat. The heating or digestion continued until each sample or solution becomes clear. The digested samples were then analyzed using Foss Tecator 2300 Keltec analyzer unit.

3. RESULTS AND DISCUSSION

From Table 1, the concentrations of the two pollutants under this study varied considerably in all the days, divisions and the sampling times. Maximum concentration (9.99mg/m^3) and the minimum concentration (0.60 mg/m^3) of NH_3 are observed in division C on Day 2.

Table 1: Results of Concentration of NH_3 and NO_2 in Divisions A, B and C of the Poultry House

	NH_3			NO_2		
	Day 1 (mg/m^3)	**Day 2 (mg/m^3)**	**Day 3 (mg/m^3)**	**Day 1 (mg/m^3)**	**Day 2 (mg/m^3)**	**Day 3 (mg/m^3)**
A_{m1}	2.07	2.16	4.30	9.82	12.50	15.17
A_{m2}	8.86	2.21	2.10	11.84	12.50	15.07
A_{f1}	1.20	2.22	2.62	11.36	13.50	19.97
A_{f2}	1.53	2.51	3.61	15.05	15.20	22.40
B_{m1}	3.56	3.06	4.42	12.55	15.10	15.02
B_{m2}	3.49	6.77	5.24	15.22	15.25	15.20
B_{f1}	1.09	6.38	4.15	17.75	15.60	20.72
B_{f2}	1.24	4.04	5.46	20.10	19.85	25.00
C_{m1}	1.50	3.28	5.50	9.87	22.47	22.60
C_{m2}	0.60	2.90	3.73	12.60	14.92	17.35
C_{f1}	2.81	2.27	4.48	14.62	15.32	17.42
C_{f2}	2.63	9.99	4.37	17.01	17.47	20.15

A_{m1} and A_{m2}: 1st and 2nd Samples in Division A Morning ; A_{f1} and A_{f2}: 1st and 2nd Samples in Division A Afternoon; B_{m1} and B_{m2}: 1st and 2nd Samples in Division B Morning; B_{f1} and B_{f2}: 1st and 2nd Samples in Division B Afternoon; C_{m1} and C_{m2}: 1st and 2nd Samples in Division C Morning; C_{f1} and C_{f2}: 1st and 2nd Samples in Division C Afternoon

Equally the maximum concentration of NO_2 (25.00 mg/m^3) was recorded in the afternoon but in Division B of the house. Furthermore, the minimum concentration of NO_2 (9.82 mg/ m^3) was detected in the morning time of the Day 1 at division A. This shows that the concentrations of the two pollutants are independent of each other. There was a fairly fixed pattern of increase in the concentration of NO_2 from morning to afternoon in all the divisions unlike NH_3 which lacks a fixed concentration distribution pattern in all the divisions. Concentrations of the gaseous pollutants obtained are relatively lower than the exposure limits of 20ppm recommended for animal welfare in Europe (CIDR,1992), except NO_2 values, 22.47ppm and 22.60ppm, recorded on days one and two for morning readings in Division C. The average distribution of the two gaseous pollutants showed that the concentration of NO_2 was almost three times the concentration of ammonia in all the divisions, days and time.

Highest average concentration of NH_3 (6.13mg/ m^3) was recorded on Day 2 at division C in the afternoon recording. The lowest concentration (1.05 mg/ m^3) was equally recorded in division C but in the morning. In all, the average concentration values (Fig 1) of NH_3 lack a definite distribution pattern. The values recorded for the morning are higher than afternoon readings in Divisions A and B while the concentrations of NH_3 for the afternoon are higher than the morning detection.

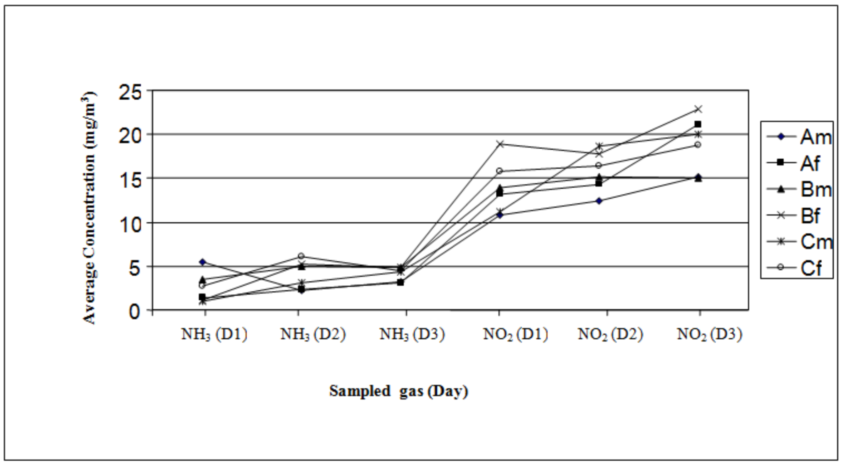

Figure 1: Average concentration of Ammonia and Nitrous Oxide detected in sampled poultry house

(D1, D2, and D3 stand for day 1, day 2 and day 3 respectively; A_m: Samples in Division A Morning; A_f: Samples in Division A Afternoon; B_m: Samples in Division B Morning B_f: Samples in Division B Afternoon; C_m: Samples in Division C Morning; C_f: Samples in Division C Afternoon)

Moreover, all the values fall within Broiler Industry Guide for ammonia concentration (<25 mg/m^3) (Carlie, 1984). The average concentration distribution of NO_2 showed an increase in the afternoon more than the morning except in division C for Day 2 and Day 3 respectively.

Relating the average concentration detected in all the divisions over the days to the number of mortality recorded (Table 2) correspondingly. The number of mortality recorded in the morning is fairly greater than those in the afternoon except for day 2 and day 3 in the division C. It follows the concentration distribution of NH_3 in the poultry house more than the distribution of NO_2.

Table 2: Mortality of Birds for Each Day

	Day 1	Day 2	Day 3
A_m	5	4	6
A_f	5	3	3
B_m	7	10	9
B_f	6	5	5
C_m	7	9	6
C_f	4	7	11

A_m: Samples in Division A Morning; A_f : Samples in Division A Afternoon; B_m: Samples in Division B Morning

B_f: Samples in Division B Afternoon; C_m: Samples in Division C Morning; C_f: Samples in Division C Afternoon

4. CONCLUSIONS

The gaseous pollutants, NH_3 and NO_2, investigated in this study were detected in the poultry and suspiciously traced to decomposition of the poultry waste generated by the birds. The mortality rate recorded in the poultry showed much similarity with the concentration distribution of NH_3 in all the divisions as well as the sampling times. It can be concluded that, NH_3, and not NO_2, as pollutant was largely responsible for the mortality rate. However, the combined adverse effects of the two pollutants on the bird's mortality cannot be overlooked. With the uneven distribution of these pollutants, it clearly required the even presence of the suction fans to take out the polluted air and make the poultry safe for use. Hence the effect of the fan distribution on the distribution of pollutants in poultry structure may need to be further investigated.

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REFERENCES

[1] Armstrong, K. A., Burns, R. T., Walker, F. R., Wilhelm, L. R and Raman, D. R. (2003), Ammonia Concentration in poultry broiler production units treated with liquid alum: In Air Pollution from Agricultural Operations III, Proceedings of the 12-15 October 2003 Conference (Research Triangle Park, North Carolina USA), Publication Date 12 October 2003. 701P1403. Pp. 116-122.

[2] Brewer, S. K. (1998), Ammonia flux from fresh, Re-used, and Alum-Treated Broiler Litter. [M.S. Thesis.] University of Arkansas, Arkansas, USA.

[3] Baracho, M. S., Nääs, I. A and Miragliotta M. Y. (2001), Evaluation of broiler housing indoor air quality during heating and during the use of two types of ventilation: natural and tunnel. In: Livestock environment VI: Proceedings of the 6th International Symposium (21-23 May 2001, Louisville, Kentucky, USA) ed. Richard R. Stowell, Ray Bucklin, and Robert W. Bottcher. 701P0201. 377-385

[4] Carlie, F. S. (1984), Ammonia in poultry houses: a literature review. World's Poult. Sci. J. 40(2): 99-113.

[5] C. B. N. (1999), Central Bank of Nigeria Annual Report and statement of Account.CBN component in broiler starter mash with *Gliricidia sepium*. Animal production in the New Millenium;challenges and options. Book of proceeding. Edited by S. Ukachuckwu *et al.*

[6] Commission Internationale Du Genie Rural (CIDR), (1992), Climatization of animal houses. Second report page 147. (State University of Ghent, Belgium, (Center for climatization of animal houses-Advisory Services).

[7] Curtis, S. E. and Drummond, J. G. (1982) Air environment and animal performance. In: R. Jr. (Ed.). CRC Handbook of agricultural productivity. Miloslav. Animal Productivity, Volume 2, CRC press, Boca Raton. FL., pp: 107-118.

[8] Donham, K. and Cumro, D. (1999), Setting maximum dust exposure levels for people and animals in livestock facilities. In: Proc. Int. Symp. Dust control in animal production facilities, May 30–June 2, Aarhus, Denmark. Danish Institute of Agricultural Sciences, Horsens, Denmark. 93–110.

[9] Donham, K. J. Cumro D. and Reynolds, S. (2002), Synergistic effects of dust and ammonia on the occupational health effects of poultry production workers. J. Agromed, vol. 8: 57–76.

[10] Feddes, J. R. and Liesko, Z. J. (1993), Air quality in commercial turkey housing. Canadan Agri. Eng., 35: 147-150.

[11] Gralapp, A. K.., Powers, W. J. and Bundy, D. S. (2001), Comparison of olfactometry, Gas Chromatography and electronic nose technology for measurement of indoor air from swine facilities. Trans. ASAE 44(5):1283-1290.

[12] Harry, E. G. (1978), Air Pollution in Farm Buildings and Methods of Control: A Review. Avian Pathol., 7: 441-454.

[13] Miner, J. R. (1995), A review of literature on the nature and control of odours from pork Production facilities Prepared for the Odour Subcommittee of the Environmental Committee of the National Pork Producers Council.

[14] Moore Jr. P. A., Daniel T. C., Edwards D. R. and Sauer T. C. (1996), Evaluation of chemical amendments to Reduce Ammonia Volatilization from Poultry Litter. Poult. Sci., 75: 315–320

[15] Nahm, K. H., (2000), A Strategy to Solve Environmental Concerns Caused By Poultry Production. World's Poultry. Sci. J., 56: 379-388.

[16] Ojo, S. O. and Afolabi, J. A. (2000), Economic analysis of replacing the fish meal publications, Abuja, Nigeria.

[17] Okoli, I. C. Alaehie, D. A. Akanno, E. C. Okoli, C. G. Opara, M. N., Uchegbu, M. C. Ogundu, U. E. and Iheukwumere, F. C. (2004), Concentrations of Aerial Pollutant Gases in Selected Poultry Pens in Imo State, Nigeria. International Journal of Poultry Science 3 (6): 427-431.

[18] O'Neil, D. H. And. Philips, V. R. (1992). A Review of control of odour nuisance from livestock buildings: parts 3, properties of the odorous substances, which have been identified in livestock, waste on in the air around them. J. Agri. Eng. Res., 58: 23-50.

[19] Persaud, K. C. (1992), Electronic gas and odour detectors that mimic chemoreception in animals. Trends Analyt. Chem. 11:61-67.

[20] Rao, C. S. (2007), Environmental Pollution Control Engineering. New Age International publishers, New Delhi. Pp424.

[21] Vučemilo, M., Matković, K., Vinković, B., Jakšić, S., Granić, K. And Mas, N. (2007), The Effect of Animal Age on Air Pollutant Concentration in a Broiler House. Czech J. Anim. Sci., 52(6): 170–174.

[22] Wathes, C.M., Holden, M.R. Sneath, R.W. White R.P., and Philips, V.R. (1997), Concentrations And Emission Rates Of Aerial Ammonia, Nitrous Oxide, Methane,Carbon Dioxide, Dust And Endotoxin In UK Broiler And Layer House. Br. Poult. Sci., 38: 14-28.

[23] Wheeler, E. F., Casey, K. D., Zajaczkowski, J. S., Topper, P. A., Gates, R. S., Xin, H. Liang, Y., and Tanaka, A. (2003), Ammonia Emission from U.S. Poultry Houses: Part III- Broiler Houses._In: Air Pollution from Agricultural Operations III. Proceedings of the 12-15 October 2003 Conference (Research Triangle Park, North Carolina USA) 701P1403. Pp. 159-166.

[24] Whyte R.T. (2002), Occupational Exposure of Poultry Stockmen in Current Barn Systems for Egg Production in the United Kingdom. Brit. Poult. Sci., 43, 364–373.

[25] Zahn, J.A., J.L. Hatfield, Y.S. Do, A.A. dispirito, D.A. Laird, and Pfeiffer, R.L. (1997), Characterization of volatile organic emissions and wastes from a swine production facility. J. Environ. Qual. 26:1687-1696.