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Factsheet 2000 #109

AMMONIA CONCENTRATIONS AND LOSSES IN LARGE LAYER BARNS

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Emissions of ammonia from poultry operations are of concern because of odour and acidification of soils due to redeposition of ammonia in precipitation. Also, release of ammonia in the exhaust air from animal buildings represents a loss of nitrogen, and hence of plant nutrient value in manure. The objective of this study was to determine losses of ammonia, during different seasons, in the exhaust air of caged-layer barns with high-rise and shallow-gutter systems for manure handling. Information was also obtained on concentrations of ammonia, carbon dioxide, methane and hydrogen sulfide gases in the exhaust air and in the vicinity of cages. During the measurement period, the high-rise barn had an average of 58,000 layers, and the shallow-gutter barn an average of 55,000 layers. Manure was normally removed once a year (in late December during this study) from the high-rise barn, and once a week from the shallow-gutter barn. Ventilation rate and gas concentration measurements were made in the high-rise barn on eight different days, when the outside air temperature ranged from -14 to +32 degrees Celsius.

Ammonia was the primary gas of interest. Gas concentrations were measured in the barn exhaust air and inside, near the cages (see **Table 1).** The net discharge of ammonia (output minus input) from the barn per unit time was calculated from the ammonia concentration in the inlet and exhaust air and the flow rate of air through the building. Concentration of ammonia in air was determined by one or more of four measurement techniques: Electronic ammonia monitors (Draeger PAC II) with electrochemical cells, Draeger long term and short term detector tubes, and diffusion tubes. In addition to ammonia gas, carbon dioxide, hydrogen sulphide, and methane concentrations were also measured using diffusion tubes.

Ventilation rate in the barns was determined using two different methods, several times per day to estimate the total air exhausted from the barn. For the duration of the monitoring period, the ventilation fans and the inlet openings were generally set at a known fixed setting to permit reasonably steady conditions for air flow into and out of the barns. Both the high-rise and shallow-gutter barns had six independent ventilation zones. Gas concentration and air flow measurements were made in each of the six zones in each barn. Actual ventilation rates were estimated to be 40% less than those calculated from fan manufacturers' rating curves due to reduced fan efficiency because of the age of the fans, dust accumulation and other factors.

Additional data were collected on outdoor weather conditions during the monitoring periods. Manure samples were collected and analyzed for dry matter, ash content, and ammonia nitrogen, and for minerals (calcium, potassium and magnesium).

Average concentrations for ammonia at the exhaust fans and near cages were generally low during summer, fall, and spring, ranging from 2 to 14 parts per million (ppm) in air in the shallow-gutter barn and 5-36 ppm in the high-rise barn **(Table 1).** During manure scraping in the shallow-gutter barn, concentration up to 55 ppm was observed near the cages because of manure disturbance. The highest concentrations, both in the exhaust air and near the cages in both barns, were recorded during the winter when the inlet air flow was low and very few ventilation fans were operating. During winter, the ammonia concentration in the shallow-gutter barn ranged from 7 to 121 ppm at the exhaust fans, and 49 to 151 ppm inside near cages. In the high-rise barn, with a year's accumulation of manure, these values ranged from 41 to 177 ppm near cages inside the barn, and from 13 to 148 ppm

Table 1: Ammonia concentrations in layer barns

Barn type	***Location of gas measurement***	***Day, Month***	***TWA* concentration range (ppm)***
Shallow-gutter	Outside at exhaust fans	03 August	2 - 11
		15 August	1 - 14
		02 October	3 - 11'
		04 December	7 - 33
		11 December	22 - 121
		22 May	1 -9
	Inside near cages	15 August	11 - 55
		02 October	14 - 19
		04 December	49 - 91
		11 December	58 - 151
		22 May	2-9
High-rise	Outside at exhaust fans downstairs	27 July	5 - 25
		29 August	7 - 34
		05 October	12 - 36
		23 November	23 - 148
		18 December	13 - 72
		04 January	4 - 56
		28 February	40 - 46
		09 May	10-50
	Inside, upstairs near cages	05 October	12 - 20
		23 November	57 - 168
		18 December	41 - 177
		04 January	4 - 20
		28 February	6 - 54
		09 May	23 - 42
	Inside, downstairs near deep manure pile	29 August	15 - 56
		05 October	49 - 116
		23 November	64 - 123
		18 December	76 - 177
		04 January	4 - 62
		28 February	32 - 82
		09 May	Not measured

*** TWA** - *Time weighted average values for the 4 to 6 hours duration of measurement.*
Range is for the six zones for ventilation in the barn.

at the exhaust fans. After manure clean-out from this barn in late December, and with a new batch of birds, concentrations in January and February in the same winter (with low ventilation rate) ranged from 4 to 20 ppm near the cages and 4 to 56 ppm at the exhaust fans. Low accumulation of manure in the high-rise barn and low temperature of the manure due to low temperature of the underlying floor resulted in a low release of ammonia gas.

There are no standards for allowable concentrations of ammonia gas in animal buildings. For poultry barns, some researchers have recommended concentration limits of 25 ppm. This concentration limit was basically met during the summer, fall, and spring because of adequate ventilation. Concentrations near the cages tended to be higher during the winter because of reduced ventilation. Certain management strategies could be used to reduce ammonia concentrations during the winter in both types of barns. Once or twice daily scraping of manure in the shallow-gutter barn, and manure clean-out at the beginning of winter prior to use of low ventilation rates in the high-rise barn, would reduce ammonia concentrations in the barns during winter. In general, frequent removal of manure from layer barns would reduce ammonia concentration in the barns.

Concentrations of hydrogen sulfide and methane gas in the exhaust air and in the barn air were low, close to atmospheric values. Concentrations of carbon dioxide were above ambient air levels but were within the generally acceptable range. As with ammonia, there are no standards for concentrations of these gases in animal buildings. For individual situations, the American Conference of Government Industrial Hygenists recommends Threshold Limit Values (TLV's) of 10 ppm for hydrogen sulfide and 5000 ppm for carbon dioxide. In terms of health effect, there is no TLV for methane although at high concentrations it could be an asphyxiant and present an explosion hazard.

Loss of nitrogen (as ammonia) in the exhaust air of the barns ranged from 0.7 to 2.4 kg/hour in the shallow-gutter barn, and 0.3 to 5.3 kg/hour in the high-rise barn (see **Table** 2). In the shallow-gutter barn, ammonia loss in the exhaust air was not much different during the different seasons. In the high-rise barn, results indicated a greater loss of ammonia in summer than in winter. This is related to the ventilation rate which was high in the summer and very low during winter.

Considering the size of the operation (more than 50,000 layers in each barn), this loss would not be economically important. Cost to recover the ammonia gas escaping in the exhaust air would be greater than the value of nitrogen recovered. Environmentally, however, ammonia emissions into the atmosphere are not desirable because of adverse effects on air quality due to odour and formation of harmful ammonium particulate compounds, and on soil quality due to acidification of soils.

After seven to twelve months of accumulation, manure in the high-rise barn had a dry matter content of about 55% compared to about 25% in the weekly-scraped shallow-gutter barn **(Table 3).** Average ash content of manure in the barns was 42% and 36% of dry matter, respectively **(Table 4).** About half of the volatile material in manure dry matter was carbon. Total nitrogen in the "wet" manure averaged 2.1% and 1.6% in the high-rise and shallow-gutter barns, respectively.

CONCLUSIONS

- At normally recommended ventilation rates, concentrations of ammonia, carbon dioxide, methane and hydrogen sulfide are not likely to be unacceptably high.
- Reduced ventilation in winter can lead to a build-up of undesirably-high concentrations of ammonia but not other gases in the vicinity of caged areas in high-rise as well as shallow-gutter barns.
- Clean-out of manure prior to start of winter accumulation (of manure) would help reduce ammonia concentrations inside the high-rise barn during winter.
- More frequent manure removal in shallow-gutter barns would help reduce ammonia concentrations inside the barn during winter.
- High-rise barns release more ammonia into the air than shallow-gutter barns because of a longer period for contact of manure with exhausting air.
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Note: *This report is based on research funded by the Poultry Industry Council.*

Table 2: Net loss of gaseous ammonia from barns *

HIGH-RISE BARN		*SHALLOW-GUTTER BARN*	
Day, Month	***Loss kg/hour***	***Day, Month***	***Loss kg/hour***
27 July	2.1 - 2.8	03 August	1.1- 1.5
29 August	4.5 - 5.3	15 August	1.9 - 2.2
15 October	3.0 - 3.1	02 October	0.0- 1.0
23 November	4.3 - 4.8	04 December	1.2- 1.3
18 December	0.8 - 1.8	11 December	2.2 - 2.4
04 January	1.2 - 1.3		
28 February	0.3 - 0.7		
09 May	1.5-1.6	22 May	0.7-1.0

* **Elemental nitrogen loss** - 0.82 X gaseous ammonia loss.

Table 3: Composition of wet (as collected) manure*

BARN TYPE	***Day, Month***	***Dry Matter %***	***TKN****	***NH4-N* * ****
Shallow-gutter	03 August	21.7	1.84	0.88
	15 August	28.6	1.62	0.81
	02 October	25.3	1.60	0.91
	04 December	23.3	1.55	0.84
	22 May	28.8	1.48	0.98
High-rise	27 July	60.3	2.05	0.83
	29 August	58.6	2.33	0.75
	05 October	57.6	2.14	0.87
	23 November	43.7	2.32	0.92
	28 February	23.3	1.36	1.22
	09 May	39.2	2.56	1.62

* Average value of six samples of manure, one from each ventilation zone, except on 15 August in shallow-gutter barn when four samples were collected, one from each gutter, while the manure was being scraped.

** **TKN** - Total Kjeldahl nitrogen (usually = total nitrogen).

* * * **NH_4-N** - ammonia nitrogen.

Table 4: Composition of manure dry matter

BARN TYPE	***Day, Month***	***Ash***	***Carbon***	***Nitrogen***	***Potassium***	***Calcium***	***Magnesium***
		- - -- - - - - - - - - - - - - - ***Dry Matter*** - - - - - - - - - - - - - - - - -					
Shallow-gutter	03 August	34.0	32.68	4.25	2.49	9.88	0.69
	15 August	36.6	31.56	3.79	2.53	12.0	0.75
	02 October	34.2	31.54	3.67	2.43	10.6	0.70
	04 December	34.0	33.99	4.67	2.53	10.5	0.67
	22 May	41.9	30.31	2.90	1.78	12.7	0.59
High-rise	27 July	41.5	29.20	3.17	3.25	12.7	0.80
	29 August	48.1	25.48	2.44	2.81	15.5	0.86
	05 October	42.1	29.19	3.33	2.76	13.0	0.78
	23 November	38.9	31.09	4.52	2.52	12.0	0.72
	28 February	38.6	29.76	3.22	2.15	12.4	0.60
	09 May	44.9	27.86	2.62	2.60	12.7	0.70