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THE MONITORING OF AMMONIA PRODUCTION IN THE BROILER HOUSING ON DEEP LITTER

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Abstract. Ammonia concentrations, ventilation rate, temperature were continuously measured and recorded in a broiler housing with 25 000 birds kept on deep litter during whole year in each growth cycle. The recorded concentrations from one of growth cycle during summer season from 30/7/2004 to 7/9/2004 were evaluated. The weekly averages of concentrations of ammonia in this housing did not exceed the suggested limit of 10 ppm and ranged from 1.68 to 6.81 ppm.

Key words: ammonia, air quality, broiler housing

INTRODUCTION

The detrimental effects of ammonia in livestock and poultry production have been known for years. Ammonia is colourless, highly water-soluble and has a sharp odour with detection threshold between 5 and 18 ppm. Numerous laboratory and field studies have shown how ammonia levels as low as 10 parts per million (ppm) affect animal health and performance. Ammonia levels above 25 ppm in the poultry house can effect both human and animal health and damage the bird's respiratory system. The U.S. Occupational Safety and Heath Administration (OSHA) indoor 8-h NH_3 exposure threshold is 25 ppm, which is similar to NH_3 threshold limits in many other countries [ACGIH, 1992]. Holub [2005] has reported the level of 10 ppm is a maximum recommended for pigs. According to Andrt [2001], the threshold limit for broilers is 25 ppm.

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Ammonia is a common by-product of animal waste due to the often inefficient conversion of feed nitrogen into animal product. Livestock and poultry are fed high-protein feed, which contains surplus nitrogen, to ensure nutritional requirements. Nitrogen that is not metabolised into animal protein (milk, meat, or eggs) is excreted in the urine and faeces of livestock and poultry where further microbial action releases ammonia into the air during manure decomposition [Jacobson et al. 2003]. A weight of the produced excrements, that is a function of animal number, their weight, a concentration of urea and another N-substances contributes directly to the production of ammonia [Dolejš et al. 2004]. A floor of broiler houses is covered with litter which becomes increasingly covered with chicken droppings during the 6–7 week growing season. The litter generally has a relatively high dry matter content (60–80%). If the litter is not removed during growing period retain a manure storage function. Spilt water, feed, feathers and dust augment the manure and litter. As bacteria break down the litter and droppings, the air becomes polluted with ammonia, dust, bacteria and fungal spores.

The positive relationship between emission and layer thickness could be explained by the larger amount of manure and thus larger amount of unionised ammonia in the litter. This means that the volatilisation of ammonia from the litter not only depends on the surface area, but also on the volume of the litter [Koerkamp et al. 1998].

MATERIAL AND METODS

For measuring ammonia concentration the device 1312 Photo-acoustic Multi-gas Monitor of firm INNOVA Air Tech Instruments with multi-channel sampling system 1309 was used. This equipment was installed in a redeveloped broiler house kept on deep litter.

The concentrations of gases NH_3, CO_2, CH_4, N_2O and water vapour were measured at five sampling points; two points at the input of the ventilation shafts F2 and F4 and two points in front of tunnel fans at the back end of the house Fb2, Fb3 (Fig. 1) and one measuring spot in outside. The concentrations and ventilation rates were continuously recorded during whole growing period in the ventilation shafts.

The object has been built from the steel structure with 22 longitudinal modules of 4.5 m, width of building is 12 m. Approximately 25 000 birds were placed in the houses immediately after hatching and grown until the market age of 49 days. After each growth cycle, the house was vacant for approximately two weeks between flocks. The facility was operated in an all-in all-out mode, i.e., building was filled with 1-day old chicks on the same day, and all finished birds were captured for market on the same day.

There has been insulated ceiling and full insulating sidewalls. Ventilation system has included six fans (9000 $m^3 \cdot hour.^{-1}$) in the roof and four tunnel fans (35 000 $m^3 \cdot hour^{-1}$). Box inlets have been located along both sidewalls and have been automatically controlled via cable based on maintenance of set point static pressure difference. Besides the measuring of concentrations there was carried out continuously measuring of indoor temperature.

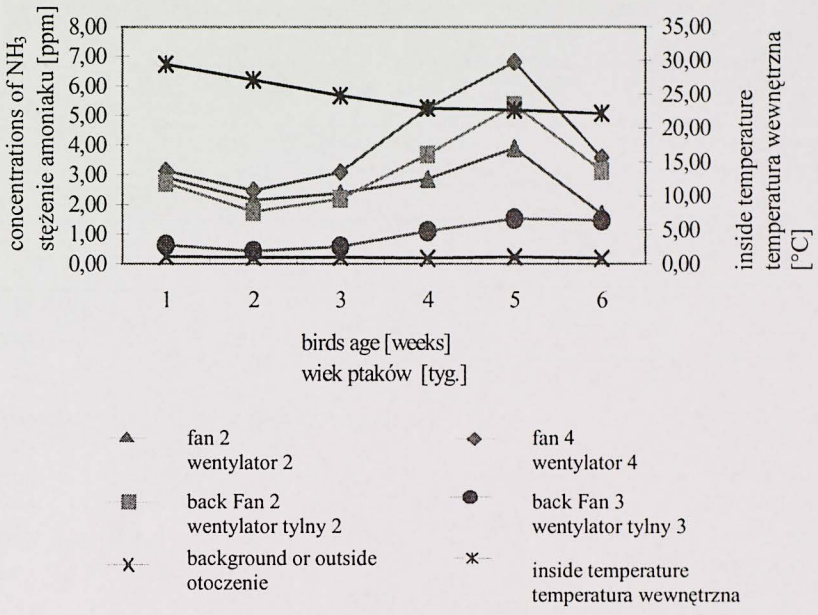

Fig. 1. Mean ammonia concentrations versus bird age during growth cycle in summer season from 30th July to 7th September

Rys. 1. Średnie stężenia amoniaku przypadające na wiek ptaków w czasie cyklu wzrostu w sezonie letnim od 30.07 do 7.09

RESULTS AND DISCUSSION

Results of continuous measuring were summarized and recalculated to weekly mean ammonia concentrations. Table 1 gives mean values, the range, standard deviation and the coefficient of variation of the ammonia concentrations. The mean ammonia concentrations in the first week ranged from 2.73 to 3.14 ppm in dependence on the measuring place. Production of ammonia slowly rose in the next weeks, the highest values were recorded in the fifth week of birds age, in range from 3.89–to 6.81 ppm. As we can see on the Figure 1, the highest concentrations in each week occurred at the second measuring spot (Fan 4), close to a middle of the house. It was probably caused by lower airflow rate or irregular distribution of the birds and thus higher moisture of the litter, which is considered one of many factors, influenced release of ammonia to the environment. As Koerkamp [1998] has reported, the distribution of droppings will depend on the distribution of the birds in space.

The ammonia concentrations were below the general threshold limit of 25 ppm for an 8 h working day for men and the living environment of animals, but sometimes exceeded the stricter limit of 10 ppm is applied in some countries mainly in the fifth week. Figure 2 shows a course of ammonia concentrations during one week. As we can see the ammonia concentrations were higher during night time operation when the ventilation system was operated at much reduced capacity.

Table 1. Weekly mean ammonia concentrations and ranges of values during growth cycle in summer season

Tabela 1. Średnie tygodniowe stężenia amoniaku oraz zakresy wartości w czasie cyklu wzrostu w sezonie letnim

Specification Wyszczególnienie	Bird age [weeks] – Wiek ptaków [tyg.] Number of measuring – Liczba pomiarów					
	1	2	3	4	5	6
	1885	1890	1860	1675	1675	995
1	2	3	4	5	6	7
1. Measuring spot F2 Average [ppm] Miejsce pomiaru F2 Średnia [ppm]	2.83	2.13	2.37	2.86	3.89	1.68
Range [ppm] Zakres [ppm]	0.82–5.14	0.86–4.50	1.02–6.57	0.81–10.36	1.45–11.25	0.95–2.99
Standard deviation Odchylenie standardowe	0.97	0.71	0.76	1.39	1.75	0.40
Coefficient of variation [%] Współczynnik wariacji [%]	34.28	33.27	32.11	48.67	45.01	23.84
2. Measuring spot F4 2. Miejsce pomiaru F4 Average [ppm] Średnia [ppm]	314	2.47	3.08	5.24	6.81	3.57
Range [ppm] Zakres [ppm]	0.81–5.61	0.95–4.56	1.32–6.32	1.15–13.17	2.79–14.38	1.99–7.65
Standard deviation Odchylenie standardowe	1.03	0.86	0.93	2.75	2.81	1.12
Coefficient of variation [%] Współczynnik wariancji [%]	32.78	34.87	30.17	52.53	41.24	31.38
3. Measuring spot Fb2 3. Miejsce pomiaru Fb2 Average [ppm] Średnia [ppm]	2.73	1.75	2.19	3.68	5.35	3.14
Range [ppm] Zakres [ppm]	0.65–5.10	0.72 3.79	0.94–4.36	1.01–9.92	1.81–11.16	1.60–5.46
Standard deviation Odchylenie standardowe	1.07	0.64	0.57	1.96	1.72	0.68
Coefficient of variation [%] Współczynnik wariancji [%]	39.21	36.68	26.03	53.22	32.16	21.69
4. Measuring spot Fb3 4. Miejsce pomiaru Fb3 Average [ppm] Średnia [ppm]	2.75	1.86	2.51	4.78	6.67	6.37
Range [ppm] Zakres [ppm]	0.52–5.17	0.85–3.707	0.791–5.02	0.62–12.02	1.17–13.86	3.311–12.76
Standard deviation Odchylenie standardowe	1.08	0.65	0.87	2.52	2.76	2.55

Table 1. cont.
Tabela 1. cd.

1	2	3	4	5	6	7
Coefficient of variation [%] Współczynnik wariancji [%]	39.34	34.87	34.63	52.68	41.39	40.04
5. Measuring spot (outside) 5. Miejsce pomiaru (na zewnątrz)						
Average [ppm] Średnia [ppm]	1.06	0.97	0.98	0.79	0.99	0.78
Range [ppm] Zakres [ppm]	0.45–2.42	0.54–1.42	0.51–1.57	0.19–1.65	0.43–1.59	0.24–1.34
Standard deviation Odchylenie standardowe	0.21	0.15	0.18	0.28	0.21	0.16
Coefficient of variation [%] Współczynnik wariancji [%]	19.81	15.46	18.37	35.44	21.21	20.51

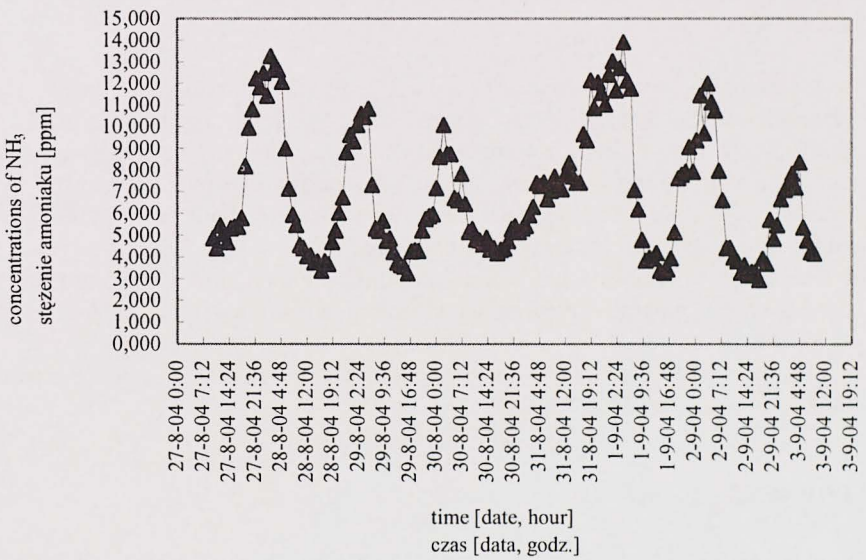

Fig. 2. Weekly profile of ammonia concentrations during fifth week of growth cycle (240 number of measuring in an each day)
Rys. 2. Tygodniowe stężenia amoniaku w czasie piątego tygodnia wzrostu (240 pomiarów w każdym dniu)

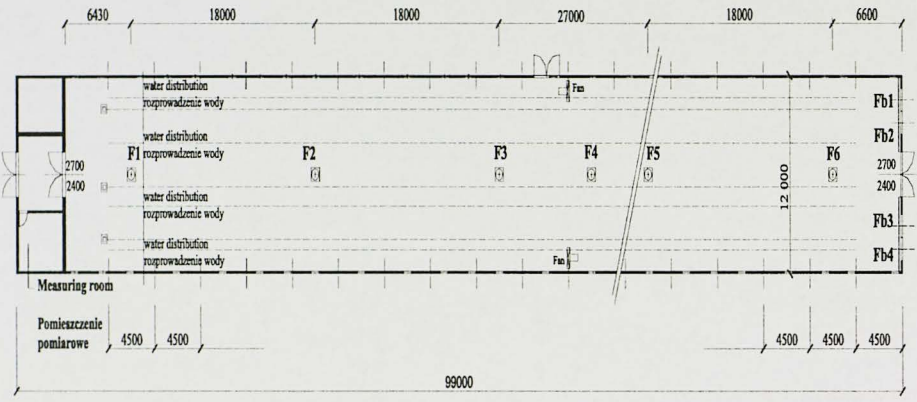

Fig. 3. Ground plan of the house
Rys. 3. Plan budynku

CONCLUSION

Mean ammonia concentrations varied from 2.73 to 3.14 ppm in the first week. However, the highest mean concentrations occurred in the five week and ranged from 3.89 to 6.81 ppm in dependence on measuring spot. The ammonia concentrations were below the general threshold limit of 25 ppm for an 8 h working day for men and the living environment of animals, but sometimes exceeded the stricter limit of 10 ppm which is applied in some countries, mainly in the fifth week.

In conclusion it possibly could be said that this operation conforms with a Act No. 245/2003 Coll. on integrated environmental pollution and prevention control valid in Slovak republic.

This results will be used as a foundation for further evaluation of amount produced ammonia emissions to the ambient air.

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MONITORING PRODUKCJI AMONIAKU W BUDYNKU DLA DROBIU Z GŁĘBOKĄ ŚCIÓŁKĄ

Streszczenie. Dokonano pomiarów koncentracji amoniaku, współczynnika wentylacji i temperatury w brojlerni przewidzianej na 25 000 brojlerów, utrzymywanych na głębokiej ściółce w ciągu całego roku, podczas wszystkich prowadzonych cykli odchowu. Oceniono wartości koncentracji zarejestrowane podczas jednego cyklu odchowu, w sezonie letnim od 30.07.2004 r. do 7.09.2004 r. Średnie tygodniowe wartości koncentracji amoniaku w tym budynku nie przekroczyły spodziewanej wartości granicznej 10 ppm. i wahały się od 1,68 do 6,81 ppm.

Słowa kluczowe: amoniak, jakość powietrza, budynek dla drobiu

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