Ammonia concentration in farrowing pens with permanent limited range of motion for lactating sows

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Abstract

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Livestock production significantly contributes to emissions of polluting gases emissions like ammonia (NH_3) and greenhouse gases. Pig production is globally responsible for about 15% of ammonia emissions. The aims of this paper were the comparison of the ammonia concentrations in the farrowing pens with permanent limited range of motion between the zones of lactating sows and piglets and the impact of the day hour on ammonia concentration in this place. Photoacoustic infrared measuring devices INNOVA were used. The average values of NH_3 concentration ranged from 0.787738 ppm (0.547478 mg/m^3) to 0.818091 ppm (0.568573 mg/m^3). The minimum concentration of NH_3 was measured in the second lactating sows zone (0.262535 ppm, 0.182462 mg/m^3) and the maximum concentration was measured in the piglets zone (1.61803 ppm, 1.124531 mg/m^3). Values measured met the requirements of the Decree No. 230/1998 of the Ministry of Agriculture and Rural Development of the Slovak Republic which allows the maximum concentration of NH_3 in the pig building 20 ppm (13.9 mg/m^3). There were no differences between the concentrations of the greenhouse gases (GHGes) in the zones of lactating sows and piglets.

Keywords: gas; farrowing pen; pig; piglet

Livestock production significantly contributes to the emissions of polluting gases like ammonia (NH_3) and greenhouse gases (Philippe et al. 2012). Ammonia is an important pollutant gas that accelerates fine particulate formation in the atmosphere and plays a crucial role in the acidification and eutrophication of ecosystem (Krupa 2003). Ammonia largely originates from agriculture representing about 95% of anthropogenic emissions (Galloway et al. 2004). The livestock sector is responsible for about 65% of global NH_3 emissions (Steinfeld et al. 2006), and pig production is globally responsible for about 15% of ammonia emissions (Olivier et al. 1998). By 2050, the global emissions of NH_3 are expected to double, principally owing to the demographic growth, changes in food preferences and the agricultural intensification (Clarisse et al. 2009). The main factors influencing NH_3 production are the floor type, the manure removal system (Mihina et al. 2011), the climatic conditions inside

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the building, diet composition, and feed efficiency of animals (Philippe et al. 2011a). Ammonia emissions are clearly correlated with the behaviour, ambient temperature, animal density (Guingand et al. 2010), ventilation system (Topisirovic et al. 2010a, b), and floor system (Philippe et al. 2006, 2010, 2011b; Cabaraux et al. 2009). The ventilation systems are mostly used to reduce and control dust concentration in pig houses (Topisirovic, Radivojevic 2005; Ecim-Djuric, Topisirovic 2010). The Decree No. 230/1998 of the Ministry of Agriculture and Rural Development of the Slovak Republic allows maximum concentration of NH_3 in the pig building to be 20 ppm.

The aims of this paper are the comparison of the ammonia concentrations in the farrowing pens with a permanent limited range of motion between the zones of lactating sows and piglets, and the impact of the day hour on ammonia concentration in this place.

MATERIAL AND METHODS

Three farrowing pens with permanent limited range of motion in the same barn were monitored. Samples of air were collected in each pen both in the lactating sows zone and the piglets zone. Monitoring was conducted during 24-h intervals with five repetitions (n = 5).

Characteristics of animals. Sows of Large White breed with their piglets were used in the experiment. Basic characteristics of the pigs are shown in Table 1.

Research place. Pigs were housed in farrowing pens with permanent limited range of motion of lactating sows. Measurements were done in the Experimental Centre for Livestock of the Department of Animal Husbandry, Faculty of Agrobiology and Food Resources, Slovak University of Agriculture in Nitra, Nitra, Slovak Republic. Pens were 2 m wide and 2.4 m long. Natural ventilation and a fully slatted floor were used. The slurry was removed twice a month, and excreta was manually mechanically removed twice a day. The lactating sows were fed by a valve for feed wetting. The piglets had their own nipple drinkers. The sampling points in the piglets zone were placed in the corner of the bedded system for piglets, at the height of 0.25 m. The sampling points in the lactating sows zone were placed in the middle of the pen, at the height of 0.5 m.

Measuring devices. Devices of INNOVA (LumaSense Technolgies, Inc., Ballerup, Denmark) were used for the measurement of the gases concentration. The measuring system consists of three main parts. The first part is INNOVA 1412 – Photoacoustic field gas-monitor. The measurement system is based on the photoacoustic infrared detection method. Gas selectivity is achieved through

Table 1. Basic characteristic of lactating sows and piglets (Dubeňová et al. 2012b)

Sample point	Sow weight (kg)	Piglets age (days)	Piglets weight (kg)		Farrowing order	No. of piglets (pcs)
			range	average		
1	303	8	1.26–2.69	1.99	5	14
2	333	15	2.35–7.50	6.03	4	6
3	304	14	3.97–5.06	4.62	3	9

Table 2. Summary statistics of ammonia concentration in lactating sows zones (LSZ, number) and piglets zones (PZ, number); n (number of measurement repetitions) = 5

Sample	Count	Average (ppm)	SD (ppm)	Coeff. of variation (%)	Min. (ppm)	Max. (ppm)
LSZ1	216	0.810339	0.309596	38.21	0.290528	1.44897
LSZ2	216	0.787738	0.324091	41.14	0.262535	1.82
LSZ3	216	0.818066	0.326329	39.89	0.317265	1.52001
PZ1	216	0.801471	0.318229	39.71	0.268961	1.61803
PZ2	216	0.789686	0.337314	42.72	0.271418	1.47976
PZ3	216	0.818091	0.339658	41.52	0.32529	1.60998

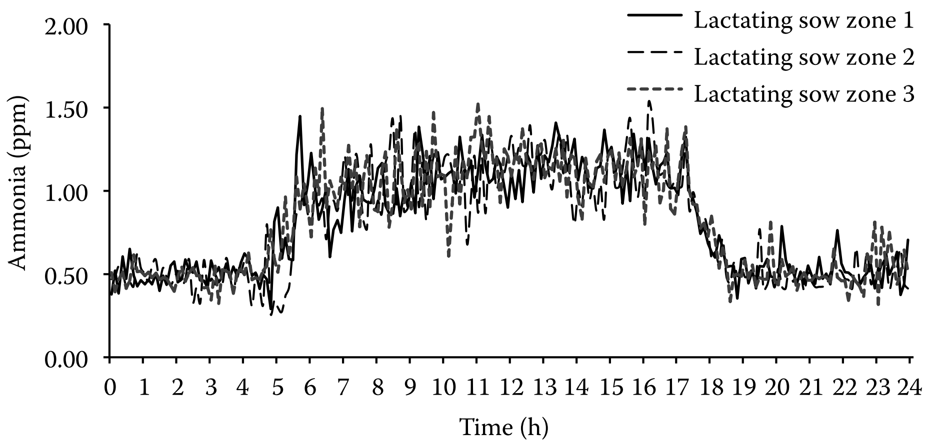

Fig. 1. Values of the ammonia concentration in lactating sows zones (n = 5)

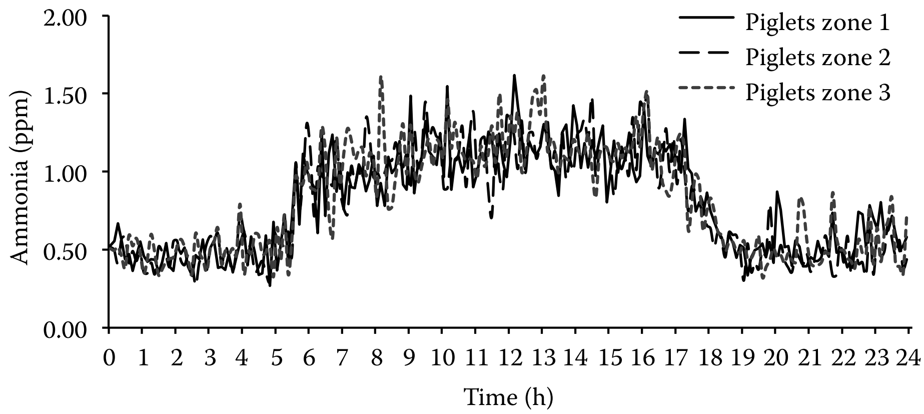

Fig. 2. Values of the ammonia concentration in piglets zones (n = 5)

the use of optical filters. The detection limit is typically in the ppb (parts per bilion) region. The second part is INNOVA 1309 – multipoint sampler. This device is a 12 channel multiplexer, enabling gas samples to be drawn from up to 12 different sampling locations and delivered to the gas monitor INNOVA 1412. The third main part is a computer with the software supplied by the manufacturer, in which the data were saved (Dubeňová et al. 2012a, b).

Statistical analysis. The data were analysed by using Kruskal-Wallis test after the normality test using Kolmogorov-Smirnov procedure and the homogeneity of variance by using Levene's test. The software used was Statgraphics Centurion XVI.I (Statpoint Technologies, Inc., Warrenton, USA). Kruskal-Wallis test tests the null hypothesis that the medians within each of the six samples are the same. Since the P-value is greater than or equal to 0.05, no statistically significant difference occurs between the medians at 95.0% confidence level.

RESULTS AND DISCUSSION

Three farrowing pens with permanent limited range of motion in the same barn were monitored. The monitoring was conducted during 24-h intervals with four repetitions. The samples of air were collected in each pen both in the lactating sow zone (LSZ, number) and in the piglets zone (PZ, number). The temperature and air humidity were measured every hour. The average value of temperature was 23.9°C and ranged from 20.3 to 27.1°C. The average value of air humidity was 58% and ranged from 44 to 67%.

The P-value in Kruskal-Wallis test was greater than 0.5 (P-value = 0.723974). No statistically significant difference was found between NH_3 concentrations in the lactating sows zones and piglets zones at the 95.0% confidence level.

The average values of NH_3 concentration ranged from 0.787738 ppm (0.547478 mg/m^3) to 0.818091 ppm (0.568573 mg/m^3)(Table 2). The min.

Table 3. Average values of ammonia concentration from 0 to 12 h/day in lactating sows zones (LSZ) and piglets zones (PZ), *n* (number of measurement repetitions) = 5

Time range (h)	Ammonia concentration (ppm)					
	lactating sow zone			piglets zone		
	1	2	3	1	2	3
0–1	0.487478	0.498806	0.48815	0.51027	0.487723	0.502955
1–2	0.476792	0.498009	0.469214	0.425147	0.430193	0.432294
2–3	0.49537	0.453164	0.482297	0.452773	0.439877	0.473201
3–4	0.516359	0.492983	0.465278	0.448497	0.521809	0.5373
4–5	0.521271	0.442154	0.550766	0.478919	0.454481	0.482604
5–6	0.888893	0.626173	0.825715	0.730717	0.754871	0.732422
6–7	0.878973	0.902006	1.030439	0.964943	0.974023	0.94646
7–8	0.973921	1.016716	1.051974	0.945156	0.992164	1.125776
8–9	0.967766	1.085553	1.044719	0.954427	1.051929	1.062095
9–10	1.111477	1.106205	1.123325	1.144718	1.184368	1.111543
10–11	1.111386	1.064309	1.078154	1.087887	1.095204	1.165268
11–12	1.111491	1.097197	1.240652	1.099056	1.051559	1.156441

concentration of NH_3 was found in the second lactating sows zone (0.262535 ppm, 0.182462 mg/m^3) and the max. was detected in the piglets zone (1.61803 ppm, 1.124531 mg/m^3). The values measured met the requirements of the Decree of the Slovak Ministry of Agriculture No. 230/1998 which allows the max. concentration of NH_3 in the pig building of 20 ppm (13.9 mg/m^3). They also met the requirement of the reference document on best available techniques for intensive rearing of

Table 4. Average values of ammonia concentration from 12 to 24 h/day in lactating sows zones (LSZ) and piglets zones (PZ), *n* (number of measurement repetitions) = 5

Time range (h)	Ammonia concentration (ppm)					
	lactating sow zone			piglets zone		
	1	2	3	1	2	3
12–13	1.095182	1.219488	1.19968	1.231693	1.182331	1.297738
13–14	1.253888	1.135958	1.148514	1.158282	1.111679	1.174325
14–15	1.145947	0.997191	1.078778	1.122504	1.216717	1.097822
15–16	1.153326	1.151786	1.174474	1.066754	1.092502	1.153028
16–17	1.134495	1.15721	1.053999	1.14801	1.163978	1.100929
17–18	0.947033	0.934847	0.980677	0.952193	0.882172	0.922263
18–19	0.577381	0.559231	0.571519	0.579131	0.562518	0.59465
19–20	0.513617	0.501596	0.524763	0.47322	0.468905	0.464848
20–21	0.53179	0.481313	0.489552	0.547354	0.437169	0.538188
21–22	0.539549	0.471461	0.492947	0.508673	0.438531	0.50466
22–23	0.483928	0.501226	0.50399	0.585442	0.443094	0.493801
23–24	0.530826	0.511125	0.563999	0.619535	0.514656	0.563569

poultry and pigs (IPPC Directive 2003) for ammonia the concentration with max. value of 10 ppm (6.95 mg/m^3). This result corresponds with our previous study where concentrations of the greenhouse gases (GHGes) CO_2, N_2O (Dubeňová et al. 2012a), and CH_4 (Dubeňová et al. 2012b) were measured in farrowing pens with permanent limited range of motion for lactating sows. No differences occurred between the concentrations of GHGes in the zones of lactating sows and piglets. The differences between the min. and max. values were 0.062755 ppm (0.043615 mg/m^3) and 0.16906 ppm (0.1175 mg/m^3). They may be caused by an increased restlessness of the lactating sows.

The differences between the NH_3 concentrations during all day are shown in Figs 1 and 2 and Tables 3 and 4 (showing the average values from all the repetitions of the measurement). The changes in concentration are shown depending on the timetable of routine day works and animals activity. The feeding started at 6:30 a.m. However, the activity of the lactating sows started about one hour before feeding and the activity of piglets started about 30 min after increasing activity of the lactating sows increased. With the lactating sows it may have been caused by the feeding time habit. The activity of the piglets depended on the sows activity. The last daily control was at 4 p.m. upon which about one hour the concentration of NH_3 decreased. This may have been caused by the decreasing activity because the animals were not disturbed by personnel.

CONCLUSION

The aim of this paper was the comparison of ammonia concentrations in the farrowing pens with permanent limited range of motion between the zones of lactating sows and piglets and the impact of the day hour on ammonia concentration in this place. There was no difference between the concentrations of GHGes in the zones of lactating sows and piglets. The average values of NH_3 concentration ranged from 0.787738 ppm (0.547478 mg/m^3) to 0.818091 ppm (0.568573 mg/m^3). The min. concentration of NH_3 was measured in the second lactating sows zone (0.262535 ppm, 0.182462 mg/m^3) while the max. concentration was measured in the piglets zone (1.61803 ppm, 1.124531 mg/m^3). The measured values found meet the requirements of the Decree No. 230/1998 of the Ministry of Agriculture and Rural Development of the Slovak Republic which allows the maximum concentration of NH_3 in the pig building to reach 20 ppm (13.9 mg/m^3). They also meet the requirement of the reference document on best available techniques for intensive rearing of poultry and pigs (IPPC Directive 2003) for ammonia concentration with max. value 10 ppm (6.95 mg/m^3).

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