Investigating the impact of manure removal frequency on the amount of produced pollutants in cattle housing

Skúmanie vplyvu frekvencie odstraňovania hnoja na množstvo vyprodukovaných škodlivín v ustajnení HD

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Abstract

The aim of the experiment was to determine the concentrations of harmful gases production in the dairy housing and to compare the difference of measured data in terms of frequency of manure removal. Measuring the concentration of ammonia, methane and carbon dioxide was carried out in summer in three-day cycles when produced excrements were removed every day at 19:00 o'clock, and in three-day cycles when removing of excreta was carried out twice a day, in the morning and evening at 5:00 and 19:00 o'clock. Microclimatic conditions during the experiment were at a comparable level, ambient temperature was maintained at about 29 °C and relative humidity was 64 %. By comparing the obtained values of production in terms of frequency of waste removal, it has been shown that for removing twice a day, the production of ammonia, carbon dioxide, methane was higher than under manure removal only once a day.

Keywords: ammonia, dairy housing, manure removal

Abstrakt

Cieľom experimentu bolo zistiť produkciu koncentrácií škodlivých plynov v objekte pre ustajnenie dojníc a porovnať rozdiel nameraných údajov z hľadiska frekvencie odstraňovania hnoja. Meranie koncentrácie amoniaku, metánu a oxidu uhličitého prebiehalo v letnom období v trojdenných cykloch, kedy vyprodukované exkrementy boli odstraňované raz za deň o 19:00 hodine a v trojdenných cykloch, kedy odstraňovanie exkrementov bolo vykonávané dvakrát za deň, ráno o 5:00 a večer o 19:00 hodine. Mikroklimatické podmienky vzduchu počas trvania experimentu boli na zrovnateľnej úrovni, teplota prostredia sa udržovala na cca 29°C a relatívna vlhkosť vzduchu 64%. Porovnaním získaných hodnôt produkcie z hľadiska frekvencie odstraňovania exkrementov bolo preukázané, že pri počte odstraňovania 2x za deň bola produkcia amoniaku, oxidu uhličitého aj metánu vyššia, ako to bolo pri vyhŕňaní len raz denne.

Kľúčové slová: amoniak, ustajnenie dojníc, odstraňovanie hnoja

Introduction

Animal manure from farms is a main source of ammonia emission pollution and greenhouse gas emissions. Significant losses of ammonia are generated in the handling of manure, application of manure to fields, manure storage and at the time of animal grazing on pastures. According to Minks (1998), the concentration of ammonia depends directly on housing and frequency of manure removal, clean stables, excrement quantity and quality. Due to a warm and humid environment in stables, there are chemical processes that can mean high losses of nitrogen. Urea is converted rapidly to ammonium carbonate due to bacteria, which is then intensively decomposed into NH_3, CO_2, and H_2O. Losses incurred in the stable are dependent on the frequency of manure removal from activity spaces (Brestenský and Botto, 2012). Kocúnová (2007) points out that good animal husbandry, for example maintaining the cleanest passageways and barnyards, contributes to lower emissions of ammonia. Konopásek (1996) reported that ammonia emissions are the greater the longer the excrements remain in the stable, the higher the temperature of the indoor air and the greater the amount of excreta is located in the zone of airflow. Animal husbandry has an important contribution not only to ammonia but also on methane emission. The main source of methane is enteric fermentation in ruminants (Olesen et al., 2006) and another important source is the decomposition of animal excreta, manure and slurry (Knížatová, 2007). Carbon dioxide is generated by the respiration of animals, natural gas for heating and decomposing organic mass in a livestock environment (Knížatová, 2008; Pattee, 2005).

Materials and Methods

The building in which the measurement is conducted is in its original condition with dimensions of 27.7 x 66.9 m. It is a loose housing of dairy cows in cubicle lyings with straw. The clear height is in the external walls 2.9 m and in the axis of the building under roof light 4.7 m. Animals are housed in four rows of cubicle lyings that are placed at external walls and in the centre of stall space. The manure corridors of width 2.6 m are along the boxes. A traversed feed passage of width 2.2 m is between mangers of width 0.8 m. Produced manure from manure passage is removed once a day in standard operation by a blade UNC loader. Within the experiment aimed to verify the claims of several authors about the impact of the frequency of waste removal on the production of ammonia and other gases, there were chosen two variants of manure removing, V1 and V2. Variant V1 means that the examination of pollutant production took place in three-day cycles during which the excreta produced were removed once a day at 19:00 o'clock. Variant V2 is the measurement in three-day cycles when the removing of excreta was conducted twice a day, at 5:00 in the morning and at 19:00 o'clock in the evening. A photo-acoustic device Photoacoustic Multi-Gas Monitor (Innova Air Tech Instruments) was used for a continuous measurement of production of harmful gases NH_3, CO_2, CH_4. To find the evidence supporting differences in the production of these gases depending on the number of manure removal during daily operations, there was used a statistical software Statistica10, two-factor ANOVA – Tukey HSD test.

There were selected sampling points of air, according to Figure 1:
point A: outdoors
point B: cubicle lying next to the external walls of the building
point C: roof light - air exhaust from the building
point D: manure corridor
point E: cubicle lying next to the external walls of the building

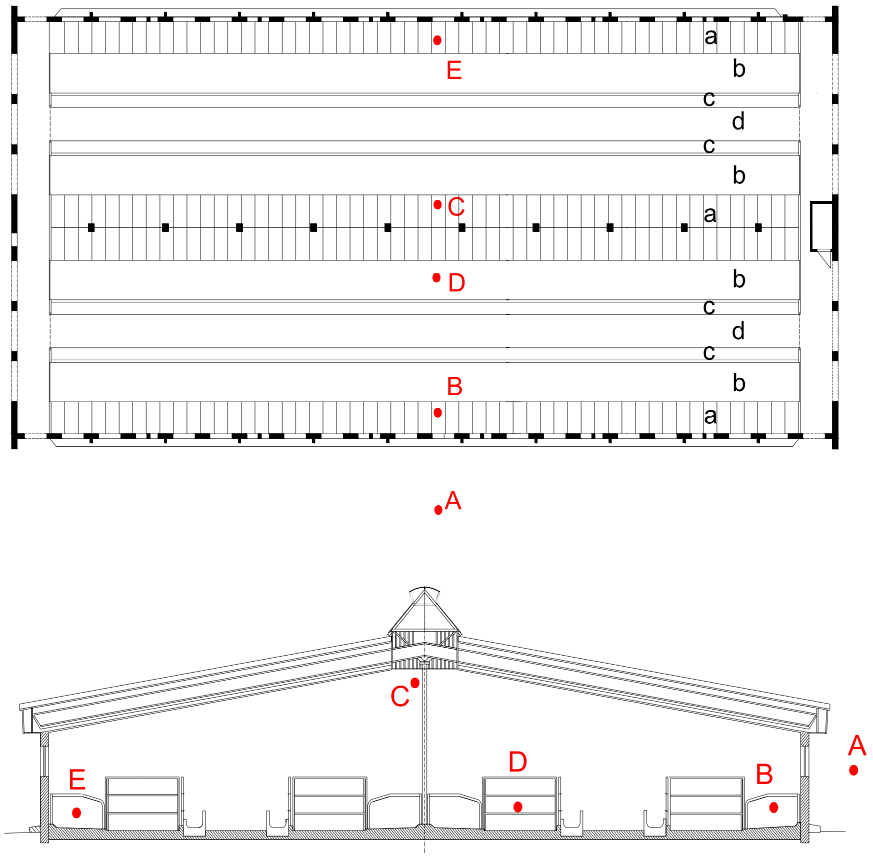

Figure 1: Plan and section of the investigated building and measuring points

a – cubicle lying, b - manure passage, c - feeding manger, d - traversed feed passage

Measurement points: A, B, C, D, E

Results

Monitored gases: NH_3, CO_2, CH_4
Compared variants of manure removal technology:
V1 - manure removal technology once a day, at 19:00,
V2 - manure removal technology twice a day, at 5:00 and 19:00.

From the measured values, there has been evaluated the production of ammonia, carbon dioxide and methane at each measuring point A-E. The processed results are shown in Table 1, 3 and 5, which indicate the average, minimum and maximum values of the surveyed gases. The highest concentration of ammonia was recorded at the measuring point D – manure passage, i.e. 1.242 mg*m^{-3} (2 ppm) for the V1 technology. For the V2 technology, the highest concentration of ammonia was recorded in the manure passage – D, i.e. 6.553 mg*m^{-3} (9 ppm). The highest concentration of carbon dioxide for the V1 technology was recorded at the measuring point D – manure passage, i.e. 1,158.90 mg*m^{-3} (631 ppm). For the V2 technology, the highest CO_2 concentration was recorded in the cubicle lying next the external wall – E, i.e. 1,692.3 mg*m^{-3} (922 ppm). The highest concentration of methane for the V1 technology was 11.650 mg*m^{-3} at the measuring point E – in the cubicle lying next to the external wall, representing 17.5 ppm. For the V2 technology, the highest concentration of CH_4 was also recorded in the cubicle lying next to the external wall – E, i.e. 29.033 mg*m^{-3} (43.5 ppm). These values occurred at the time of removal of excreta after 19:00 o'clock and became somewhat stabilized at night. In the morning, after a repeated removal, they again increased to the maximum value, and during daily operation, values had a slightly variable pattern. For the evaluation of measured data, there was used the two-factor ANOVA – Tukey HSD test (Tables 2, 4, 6). These results show that monitored gas production did not differ significantly when comparing the different measurement points A-E. The results highly statistically significantly differed in terms of waste removal frequency. It turned out that with the number of removal twice a day (variant V2), the production of ammonia, carbon dioxide and methane was significantly higher (P<0.01) than in case of manure removal only once a day (variant V1), Table 2, 4 and 6.

Table 1: Resulting values for ammonia concentrations at measurement points A-E, mg*m^{-3}

Manure removal once a day	***A***	***B***	***C***	***D***	***E***
Average	0.310	0.301	0.310	0.315	0.295
Standard deviation	0.247	0.237	0.234	0.236	0.238
Minimum	0.001	0.000	0.000	0.005	0.000
Maximum	1.185	1.122	1.174	1.242	1.155
Number of measurements	832	832	832	832	832
Manure removal twice a day	***A***	***B***	***C***	***D***	***E***
Average	0.836	0.829	0.825	0.833	0.829
Standard deviation	0.564	0.545	0.548	0.547	0.555
Minimum	0.001	0.003	0.004	0.010	0.000
Maximum	6.145	5.263	6.116	6.553	6.314
Number of measurements	832	832	832	832	832

Table 2: Tukey HSD test; variable NH_3, mg*m^{-3}; homogeneous groups, P<0.01

Measuring point	***Number of manure removals a day***	***NH_3, mg*m^{-3}***	***1***	***2***
E	V1	0.293841	****	
B	V1	0.301357	****	
C	V1	0.309328	****	
A	V1	0.310138	****	
D	V1	0.314217	****	
C	V2	0.824692		****
E	V2	0.828509		****
B	V2	0.829056		****
D	V2	0.833445		****
A	V2	0.836211		****

Table 3: Resulting values for carbon dioxide concentrations at measuring points A-E, mg*m^{-3}

Manure removal once a day	***A***	***B***	***C***	***D***	***E***
Average	899.883	900.347	899.783	900.010	899.701
Standard deviation	59.474	59.660	57.392	57.000	56.932
Minimum	605.160	620.600	613.900	613.150	652.080
Maximum	1148.500	1146.300	1119.400	1158.900	1140.400
Number of measurements	832	832	832	832	832
Manure removal twice a day	***A***	***B***	***C***	***D***	***E***
Average	1032.373	1032.373	1032.305	1032.442	1031.854
Standard deviation	120.710	120.844	121.523	121.647	119.684
Minimum	797.880	787.030	791.440	787.980	794.680
Maximum	1672.300	1653.200	1651.800	1675.000	1692.300
Number of measurements	832	832	832	832	832

Table 4: Tukey HSD test; variable CO_2, mg*m^{-3}; homogeneous groups, P<0.01

Measuring point	***Number of manure removals a day***	***CO_2, mg*m^{-3}***	***1***	***2***
E	V1	899.701	****	
C	V1	899.783	****	
A	V1	899.883	****	
D	V1	900.010	****	
B	V1	900.347	****	
E	V2	1,031.854		****
C	V2	1,032.305		****
A	V2	1,032.373		****
B	V2	1,032.373		****
D	V2	1,032.442		****

Table 5: Resulting values for methane concentrations at measuring points A-E, mg*m^{-3}

Manure removal once a day	***A***	***B***	***C***	***D***	***E***
Average	4.009	4.011	3.963	3.964	3.988
Standard deviation	1.658	1.680	1.636	1.663	1.647
Minimum	0.457	0.205	0.092	0.154	0.504
Maximum	11.619	11.419	10.809	11.111	11.650
Number of measurements	832	832	832	832	832
Manure removal twice a day	***A***	***B***	***C***	***D***	***E***
Average	8.362	8.358	8.368	8.361	8.353
Standard deviation	2.905	2.918	2.942	2.962	2.884
Minimum	0.727	1.086	0.290	0.820	1.801
Maximum	28.538	25.318	25.548	27.524	29.033
Number of measurements	832	832	832	832	832

Table 6: Tukey HSD test; variable CH_4, $mg*m^{-3}$; homogeneous groups, P<0.01

Measuring point	***Number of manure removals a day***	***CH_4, $mg*m^{-3}$***	***1***	***2***
C	V1	3.963270	****	
D	V1	3.963511	****	
E	V1	3.987585	****	
A	V1	4.008516	****	
B	V1	4.010800	****	
E	V2	8.352731		****
B	V2	8.358390		****
D	V2	8.361261		****
A	V2	8.362294		****
C	V2	8.368443		****

Discussion

On the basis of experimental measurements, it can be concluded that the results do not correspond to the claims of, e.g. Konopásek (1996) that ammonia emissions are the greater the longer the excretions remain in the barn. There has been confirmed the fact that significant gas releases occur with manure handling. Therefore, important is not only a frequent waste removal but also, as stated by Braam et al. (1997), reductions of ammonia emissions in cattle breeding by up to 65 % is possible using a combination of scraping and spraying the floor with water. The showering floors system reduces the concentration of urea and simultaneously removes urine from the floor surface. Only scraping without showering with water leaves a thin surface layer, which is a major source of leakage of ammonia (Braam et al., 1997). Adding formaldehyde to flushing water reduced volatilization from dairy barns by 50 % compared to 14 % in barns flushed with water only. Formaldehyde inhibits urease activity, which is more effective than dilute urine and its removing. The disadvantage of using formaldehyde is the formation of formaldehyde vapour, which may have negative effects on the health of animals (Monteny, 2000).

Acknowledgement

This contribution has been supported by the project VEGA 01/0609/12.

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