Impact of alternative air exhaustion in housing for poultry on concentration of harmful gases in the air

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Abstract: The main aim of the paper is to assess an alternative way of disposal of pollutants from housing area, where the air is sucked from spaces below the animals. Measurements were taken in experimental conditions of enriched cage for 10 hens. Pipe for suction was located under the floor of the cage. Gas concentration was determined by the device 1412 Photo acoustic Multi-gas Monitor. Air samples were collected at the animal's head level. Air temperature was continuously registered and air velocity was measured. Measurements were conducted for six consecutive days in each season of the year (spring, summer, autumn and winter). The obtained results were compared with the concentration of harmful gases obtained without the use of the exhausting device. Average values of harmful gases concentrations obtained with utilisation of air suction device placed under the floor of the cage were almost in all cases lower. According to season of the year they varied without air suction device in CO_2 832.06 to 1000.75 mg/m^3 versus 813.405 to 957.59 mg/m^3 with the device exhausting air from the space under the floor. In N_2O it was 0.951 to 1.076 mg/m^{-3} compared with 0.972 to 1.055 mg/m^3, in NH_3 from 0.013 to 0.092 mg/m^3 compared with 0.007 to 0.069 mg/m^3, in H2S from 0.171 to 0.579 mg/m^3 compared with 0.17 to 0.436 mg/m^3 and in CH_4 2.076 to 7.211 mg/m^3 compared with 1.516 to 5.018 mg/m^3. Changing the way of housing ventilation significantly reduced the air flow rate at the level of laying hens' heads, too. In winter, it was on average 0.6 m/s in traditional with a fan placed in the wall compared to 0.11 m/s in ventilation by tubes located beneath the floor of the cage. In summer it was much higher 1.2 m/s compared to 0.15 m/s. While the temperature at the level of birds' heads was in winter season higher at the alternative way of ventilation (23.9^{0}C compare to 18.1^{0}C), it had slightly opposite effect during the other seasons in this experiment. This finding needs additional research.

Keywords: hens, housing, air pollutants, exhausting under cage floor

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1 Introduction

Production of gases in the conventional livestock industry affects the environment and climate. In poultry husbandry, there are produced mainly ammonia (NH_3), carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4). Ammonia is a toxic gas with a direct negative effect on the environment. Methane is a classic greenhouse gas that along with carbon dioxide (CO_2) and nitrous oxide (N_2O) causes warming of the atmosphere (Weiske and Petersen 2006;Knížatováet al., 2010).

Gaseous NH_3 is the predominant pollutant in poultry systems. Higher concentrations adversely affect bird performance, welfare, and human health (Costa et al., 2012). Elevated concentrations of NH_3 in poultry barns reduce feed intake and impede bird growth rate, decrease egg production, damage the respiratory tract, increase the incidence of diseases (Kristensen, Wathes, 2000). Egg quality may also be adversely affected by high levels of atmospheric ammonia (Xin et al., 2011).

Animal farms, including the poultry ones can cause many pollution problems and at the same time pollutants are

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harmful for animals themselves. Therefore, at present it is important to use effective production systems in poultry husbandry, which do not impair the human and animal environment through missions of harmful gases. Best practices and technological advances should be used in order to achieve the most advantageous overall environment. The environment in the poultry housing is a combination of physical and biological factors which interact as a complex dynamic system of social interactions, husbandry system, light, temperature and the aerial environment (Hobbs et al., 2004). The high stocking density in the modern poultry barns may lead to reduced air quality with high concentrations of organic and inorganic dust, pathogens and other micro-organisms as well as mentioned harmful gases (Ellen, 2005; Gates et al., 2008).

The production and emission of gases in poultry as in any livestock facilities involve complex biological, physical, and chemical processes. The rate of emission is influenced by many factors (Xin et al., 2011). These are primarily the number and live weight of housed animals, floor surface covered with their excrements, manure storage time in housing area, performance of ventilation, air temperature, season of the year, air movement above the litter surface or not bedded barn floor, air permeation through the litter, litter temperature, its moisture, pH, the ratio C:N and feed composition (Coufal, 2006; Dolejš et al., 2007; Mihina et al., 2012a).Production of mentioned gases, which are one of sources of global problems and significantly deteriorate the standard of local life for animals and stockmen, can be reduced by various and technological interventions (Metz 2002;Gay and Knowlton, 2005;Pratt et al.,2006).

Animal environment is characterised by parameters of microclimate. Microclimate is an essential factor of production and subsistence in animal husbandry. Its quality affects structural design of the building, construction insulation structures, but also the effectiveness of the ventilation system(Balkova et al., 2009).

Conventional ventilation, i.e. exhaustion of polluted air from animal housing, does not provide sufficient air exchange (Havlíček et al., 2007; Knížatová et al., 2008;Karandušovská et al., 2009).First of all, microclimatic parameters are not the same for all animals; animals are often in draft, and the heat produced by animals is exhausted sometimes even excessively (Karandušovská et al., 2009).Therefore, it is important to optimize the location and performance fans of an exhaust system. However, it must be careful not to over-boost performance of fans or to cause drafts (Pogranetal., 2011).Not sufficient air exchange often increases humidity of faeces, which causes the possibility of higher production of harmful gases. Droppings of laying hens are therefore dried. This system decreases emissions of gases quit well, however, energy consumption is increased. In this paper an alternative way of pollutants disposal from the housing area is assessed, namely, the air being sucked from spaces below the animals.

2 Material and methods

The experiment was conducted from January 2012 to October 2012 in an experimental hen's barn at the Faculty of Engineering of the Slovak University of Agriculture. Ten hens were group housed in a commercial enriched cage. Two different ways of polluted air exhaustion were used: (1) traditional with a fan placed in the wall (263 m^3/h in summer season and 139 m^3/h in autumn, winter and spring; and (2) by tubes located beneath the floor of the cage connected with the same fan (153 m^3/h in summer season and 109 m^3/h in autumn, winter and spring).

Concentration of harmful gases as carbon dioxide (CO_2), nitrous oxide (N_2O), ammonia (NH_3), hydrogen sulphide (H_2S) and methane (CH_4), flow of air and air temperature at the level of birds heads were assessed during every season of the year (winter, spring, summer and autumn) for six consecutive days of using each way of ventilation.

Gas concentration in collected air samples was determined using the 1412 Photo acoustic Multi-gas Monitor. Air temperature was continuously registered using a COMMETER D3120 (accuracy ±0.2 ℃), and air velocity was measured by the ALMEMO 3290 anemometer(accuracy ±0.04 m/s).

Data were elaborated in the system Satistica by One way ANOVA. Differences between data obtain under different ways of air exhausting were tested by Student's *t*-test.

3 Results and discussion

The results under different ways of air exhausting from the housing of laying hens are given in Table1, Table 2, Table 3, Table 4 and Table 5andFigure1.

Table 1 Average concentration of CO_2 using different ways of air exhaustion from the housing of laying hens in mg/m^3

Air exhaustion		Winter	Spring	Summer	Autumn
fan in the wall	n	1658	1585	1539	2007
	average	832.063^a	914.417^a	1000.75^a	907.636^a
	st. dev.	31.498	61.826	58.212	36.14
beneath the cage	n	1649	1761	1411	1899
	average	813.405^b	887.907^b	957.59^b	908.115^a
	st. dev.	37.695	42.216	61.901	63.913

Note: Means in column with different letters “a,b” differ at P≤ 0.05level.

Table 2 Average concentration of N2O using different ways of air exhaustion from the housing of laying hens **in mg/m3**

Air exhaustion		Winter	Spring	Summer	Autumn
fan in the wall	n	1658	1585	1539	2007
	average	1.076^a	0.975^a	1.033^a	0.951^a
	st. dev.	0.061	0.075	0.116	0.077
beneath the cage	n	1649	1761	1411	1899
	average	1.055^b	0.972^a	1.005^b	0.982^b
	st. dev.	0.063	0.072	0.094	0.073

Note: Means in column with different letters “a,b” differ at P≤ 0.05level.

Table 3 Average concentration of NH_3 using different ways of air exhaustion from the housing of laying hens in mg/m^3

Air exhaustion		Winter	Spring	Summer	Autumn
Fan in the wall	n	1658	1585	1539	2007
	average	0.048^a	0.092^a	0.086^a	0.013^a
	st. dev.	0.007	0.012	0.145	0.047
Beneath the cage	n	1649	1761	1411	1899
	average	0.031^b	0.063^b	0.069^b	0.007^b
	st. dev.	0.053	0.1	0.113	0.035

Note: the different letters “a,b” differ at P≤ 0.05level.

Table 4 Average concentration of H2S using different ways of air exhaustion from the housing of laying hens **in mg/m3**

Air exhaustion		Winter	Spring	Summer	Autumn
Fan in the wall	n	1658	1585	1539	2007
	average	0.171^a	0.33^a	0.579^a	0.307^a
	st. dev.	0.025	0.089	0.133	0.064
Beneath the cage	n	1649	1761	1411	1899
	average	0.17^a	0.31^b	0.436^b	0.217^b
	st. dev.	0.022	0.115	0.121	0.091

Note: Means in column with different letters “a,b” differ at P≤ 0.05level.

Table 5 Average concentration of CH4 using different ways of air exhaustion from the housing of laying hens **in mg/m3**

Air exhaustion		Winter	Spring	Summer	Autumn
Fan in the wall	n	1658	1585	1539	2007
	average	2.076^a	3.071^a	7.211^a	3.233^a
	st. dev.	0.126	1.393	1.892	0.892
Beneath the cage	n	1649	1761	1411	1899
	average	2.111^b	2.838^b	5.018^b	1.516^b
	st. dev.	0.14	1.905	1.889	1.442

Note: Means in column with different letters "a,b" differ at $P \leq 0.05$level.

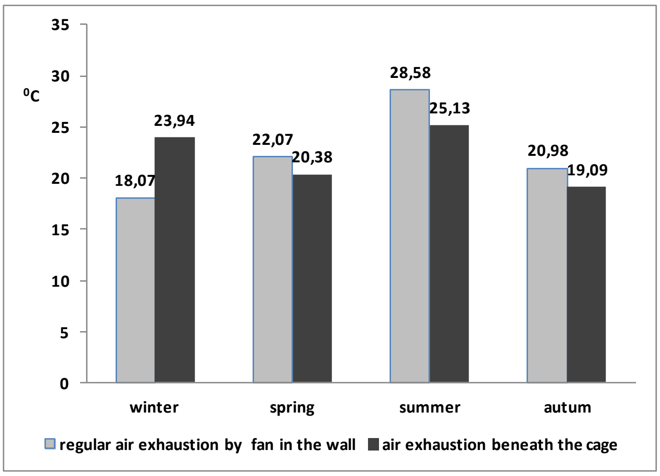

Figure 1 Average temperature at different ways of air exhaustion from the housing of laying hens

Average CO_2 concentration at the regular ventilation by fan placed in the wall of experimental barn varied from 832.063 mg/m^{3}in the winter period to 1000.75 mg/m^{3}in summer (Table 1). If the air exhausting system beneath the cage floor was used, the concentration of CO_2 was lower in all seasons (from 813.405 mg/m^{3}in winter to 957.59 mg/m^3 in summer).Data obtained from the air at the level of bird's heads in the housing system with the ventilation of the space beneath the floor of the cage were in winter, spring and summer significantly lower than in the system with the fan placed in the wall.

Average N_2O concentration at the regular ventilation by fan placed in the wall of experimental barn ranged from 0.951mg/m^{3}in autumn to 1.076mg/m^{3}in winter (Table 2). At the air exhausting system beneath the floor of the cage the concentration of N_2O varied from 0.972 mg/m^3 in spring to 1.055 mg/m^3 in winter. Average concentration of N_2Oat the level of birds heads in the housing system with the ventilation of the space beneath the floor of the cage were significantly lower than in the system with the utilisation of the regular ventilation by the fan placed in the wall only in winter and summer. In spring there was not significant difference and in autumn N_2O concentration was even higher in the system with the fan placed in the wall.

Average NH_3 concentration at the regular ventilation by fan placed in the wall of experimental barn varied from 0.013mg/m^{3}in autumn period to 0.092mg/m^{3}in summer (Table 3). If the air exhausting system beneath the cage floor was used the concentration of NH_3 was significantly lower in all seasons (from 0.007mg/m^{3}in autumn to 0.069 mg/m^3 in summer).

Both H_2S concentration and CH_4 concentration in air samples taken at the level of bird's heads had similar tendency. Almost in all cases it was significantly lower when the air was exhausting from the space beneath the floor of the cage than at the utilisation of the regular ventilation by the fan placed in the wall. (Table 4 and Table 5).

Change of the ventilation way in a hen's barn significantly reduced the rate of air flow at the level of laying hens' heads. In winter, it was on average 0.61(from 0.54 to 0.65) m/s compared to 0.11(from 0.08 to 0.13)m/s, in spring at the same level, in summer 1.22 (from 1.17 to 1.28) m/s compared to 0.15 (from 0.12 to 0.17) m/sand in autumn0.45 (from 0.42 to 0.53)m/s compared to 0.14 (from 0.12 to0.15)m/s. It is possible to assume that the change of the way of air exhaustion can reduce also the removal of heat produced by birds. While the temperature at the level of birds' heads was higher in winter season at the alternative way of ventilation, during the other seasons it had slightly opposite effect (Figure1).This needs additional research.

4 Conclusions

The main aim of the paper is to assess an alternative way of pollutants removal from housing area, where the air is sucked from spaces below the animals. The obtained results with fan beneath the cage were compared with the concentration of harmful gases obtained with fan in wall.

Average values of harmful gases concentrations obtained with utilisation of air suction device placed under the floor of the cage were almost in all cases significantly lower.

Change of the way of housing ventilation significantly reduced the rate of air flow at the level of laying hens' heads, too.

While the temperature at the level of birds' heads was in winter season higher at the alternative way of ventilation during the other seasons it had slightly opposite effect. This needs additional research.

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